The passenger-to-freighter conversion market is now becoming more active as airlines consider fleet renewals. The availability of medium widebodies is increasing. Airlines need to weigh up the cost of acquiring a freighter with future operating costs and revenue generating capacity.

Revenue capacity of the A300-600RF, A310-300F, 767-200SF & 767-300SF

Medium widebodies are now available in large numbers and values are at a level that makes total production cost and subsequent lease rates for a converted freighter economic in comparison to older generation types like the DC-8-60/-70, A300B4 and DC-10-30. While the air freight market has seen weak volumes and yields for the past four years, a recovery would see demand for the A300-600F, A310-300F, 767-200SF and 767-300SF increase from current levels. Aircraft would be needed to replace older fleets and provide capacity for traffic growth.

The selection of these types will depend on two main factors: their lease rates or acquisition cost; and operating economics. Operating economics is an issue of gross profit generating potential, rather than just operating costs. That is, two types of similar size may have close trip costs on the same mission or route network, but the aircraft with a higher revenue generating capacity will have the greater economic potential. Freight yields are generally low and so freighter aircraft only generate profits when load factors are high.

Commonality issues mean that most airlines will select either the A300-600/A310-300 or 767-200SF/-300SF, rather than one Airbus type and one Boeing type. This raises the issue of which combination will have the greater payload capacity and revenue generating potential.

Freighter roles

The four aircraft under consideration already operate with several airlines in different roles, such as US domestic, trans-European, transatlantic and trans-Asian express package operations. The largest operators of the A300-600 are UPS and FedEx, while DHL uses the aircraft from Hong Kong. The A310 is flown only by FedEx in this role.

The 767-300 has so far only been available as a factory-built freighter from Boeing, and is used by UPS. The 767-200 is used for express package operations by ABX, although this is with a unique freighter conversion configuration.

The 767-200SF is now used by Tampa Air Cargo in Colombia for carrying general freight. The 767-300SF is not yet available, although several airlines use the factory-built aircraft for general freight.

Utilising these four aircraft for express package operations will require medium-range capability in most cases, although some carriers will require longer-range capability for markets such as the transatlantic. Examples of general freight operators are those flying between Europe and the Middle East/Africa and between North and Latin America. Airlines operating these markets are more likely to have a longer range requirement. Revenue generating ability or operating economics of these aircraft is therefore also affected by range performance.

Several different stage lengths are representative of typical operations for the four types where available payload and revenue generating ability should be analysed. A 1,500nm sector length might be representative of the longest likely stage length for most express package operations, while a 2,500nm distance will be representative for general freight operations.

Available payload is first determined by the payload-range performance of each aircraft, and the gross structural payload of each type for a given range dictates the maximum weight that can be carried. Structural payload is the difference between maximum zero fuel weight (MZFW) and operating empty weight (OEW). The structural payload reduces at longer ranges once maximum take-off weight (MTOW) is reached, and each aircraft's payload-range profile will determine the actual structural payload that is possible for a particular range. The payload-range profile for each aircraft assumes still air conditions en route, however. Actual head or tail winds, plus possible take-off or landing weight restrictions, can reduce actual available payload compared to that shown on the payload-range chart.

In addition to available payload, consideration also has to be given to the tare weight of freight containers or pallets which is added to the aircraft's OEW, thereby reducing structural payload for any given sector length.

Actual available payload is then determined by the total available volume of each type's upperdeck and lowerdeck containers and small additional volume provided by bulk capacity in the aft lower deck, multiplied by the packing density of the freight. There are several total available volumes for each aircraft, since there are several container and pallet configurations for each aircraft type.

A300-600F

The A300-600 was built in limited numbers, and EADS-EFW is the only provider of a conversion programme. A small number of the passenger-configured aircraft built have been converted, while most passenger-configured aircraft remain

PAYLOAD CHARACTERISTICS A300-600F & 767-300SF

Aircraft type	EADS-EFW A300-600F	Boeing/Aeronavali 767-300SF/-300ERSF	Bedek 767-300ERSF
MZFW-lbs	286,600	278,000/295,000	295,000
OEW-lbs	179,230	182,900/184,100	180,700
Gross structural payload-lbs	107,370	95,100/110,900	114,300
Type maindeck containers	88" X 125" X 96"	88" X 125" X 96"/A2 ULD	88" X 125" X 96"/A2 ULD
Number maindeck containers	21	22/2	22/2
Unit volume maindeck containers-cu ft	476	502	502
Unit tare weight maindeck containers-lbs	253	240	240
Total volume maindeck containers-cu ft	9,996	11,884	11,884
Total tare weight maindeck containers-lbs	5,313	5,760	5,760
Type lowerdeck containers	LD-3	LD-2	LD-2
Number lowerdeck containers	22	30	30
Unit volume lowerdeck containers-cu ft	146	124	124
Unit tare weight lowerdeck containers-lbs	215	203	203
Total volume lowerdeck containers-cu ft	3,212	3,720	3,720
Total tare weight lowerdeck containers-lbs	4,730	6,090	6,090
Total volume all containers-cu ft	13,208	15,604	15,604
Total tare weight all containers-lbs	10,043	11,850	11,850
Net structural payload-lbs	97,327	83,250/99,050	102,450
Maximum packing density-lbs/cu ft	7.37	5.34/6.35	6.57
Volumetric payload @ 6.5lbs/cu ft	85,852	83,250/99,050	102,450
Volumetric payload @ 7.0lbs/cu ft	92,456	83,250/99,050	102,450

in service with their original operators.

The A300-600 is the natural successor to the A300B4-100F/-200F. About 60 of these aircraft were converted from passenger aircraft in the mid 1990s, but most are now 20-25 years old. The A300B4 has an eight-year calendar limit on its higher structural check. This raises the issue of whether to invest in this maintenance visit and attempt to keep the aircraft operational for up to another eight years, or whether to replace it when the aircraft approaches its third structural check at 24 years old. Many A300B4 operators have complained about the A300B4's maintenance costs, in particular its engines which have high reserves, especially on short cycles.

The first A300-600s were built in 1984, and so are 20 years old. The A300-600 not only has significantly lower engine maintenance reserves, but also lower airframe-related maintenance costs, lower fuel burn and lower flight crew costs than the A300B4. The A300-600 also has a higher MTOW and structural payload, and longer range.

The A300B4-100F's gross structural payload varies from 90,390lbs to 99,210lbs with different MZFW options, while the –200F's structural payload is 93,480lbs and 97,890lbs. The A300B4-100F can only carry its full payload about 1,600nm, while it has a payload performance capacity of about 73,000lbs at 2,500nm.

The A300B4-200F can carry its full payload just over 2,000nm, and has a payload performance capacity of about 85,000lbs at 2,500nm.

The A300-600RF has two MTOW variants of 375,900lbs and 378,530lbs. The aircraft has a MZFW of 286,600lbs and OEW, not including tare weight of freight pallets or containers, of 179,230lbs. This gives the aircraft a gross structural payload of 107,370lbs *(see table, this page)*. This is 8,000-17,000lbs more than the A300B4-100F/-200F. The higher MTOW variant gives it about 100nm more range than the lower weight model. Range with full payload is about 2,600nm. Payload capability at 4,000nm is about 66,000lbs.

The A300-600RF can accommodate various maindeck container configurations. The best use of the aircraft's upper deck fuselage cross-section is to load 88-inch wide X 125-inch long X 96-inch contoured containers side by side. The A300-600RF has a longer fuselage than the A300B4, allowing the –600RF to carry 21 *(see table, this page)*; one more than the A300B4. Each of these containers has an internal volume of 476 cubic feet and tare weight of 253lbs. This takes total maindeck containerised volume to 9,996 cubic feet and tare weight to 5,313lbs *(see table, this page)*.

The A300-600 can accommodate 22 LD-3 containers in its underfloor compartment which are two more than the A300B4 can. Each has an internal volume of 146 cubic feet and tare weight of 215lbs. This takes total underfloor volume to 3,212 cubic feet and tare weight to 4,730lbs *(see table, this page)*. Total containerised volume for the aircraft is 13,208 cubic feet and tare weight to 10,043lbs *(see table, this page)*.

The tare weight of containers, in this configuration, takes net structural payload down to 97,327lbs *(see table, this page)*. This net structural payload can be utilised in the containerised volume of 13,208 cubic feet, allowing a maximum packing density of 7.37lbs per cubic foot *(see table, this page)*. When freight is packed at 6.5lbs per cubic foot, typical for express package operations, the aircraft has a volumetric payload of 85,852lbs. A higher packing density of 7.0lbs per cubic foot takes volumetric payload to 92,456lbs.

EADS-EFW A310-300F

The A310-300 is the smaller alternative to the A300-600. The A310 has a shorter fuselage so it accommodates fewer containers. There are two basic A310 variants: the lower weight –200; and higher weight –300. The A310-200 has a lower MZFW and structural payload than the –300, but the two have identical freight volumes and container tare weights. The A310-200F therefore has a lower maximum packing density, and also has a lower MTOW and shorter range. The A310-200F is therefore more

PAYLOAD CHARACTERISTICS A310-300F & 767-200SF

Aircraft type	EADS-EFW A310-300F	Boeing/Aeronavali 767-200ERSF	Bedek 767-200SF
MZFW-lbs	251,320	258,000	258,000
OEW-lbs	162,920	164,600	164,000
Gross structural payload-lbs	88,400	93,400	94,000
Type maindeck containers	88" X 125" X 96"	88" X 125" X 96"/A2 ULD	88" X 125" X 96"/A2 ULD
Number maindeck containers	16	20	18
Unit volume maindeck containers-cu ft	476	502	502
Unit tare weight maindeck containers-lbs	253	240	240
Total volume maindeck containers-cu ft	7,616	9,876	9,876
Total tare weight maindeck containers-lbs	4,048	4,800	4,800
Type lowerdeck containers	LD-3	LD-2	LD-2
Number lowerdeck containers	14	22	22
Unit volume lowerdeck containers-cu ft	146	124	124
Unit tare weight lowerdeck containers-lbs	215	203	203
Total volume lowerdeck containers-cu ft	2,044	2,728	2,728
Total tare weight lowerdeck containers-lbs	3,010	4,466	4,466
Total volume all containers-cu ft	9,660	12,604	12,604
Total tare weight all containers-lbs	7,058	9,266	9,266
Net structural payload-lbs	81,342	84,134	84,734
Maximum packing density-lbs/cu ft	8.42	6.68	7.72
Volumetric payload @ 6.5lbs/cu ft	62,790	81,926	81,926
Volumetric payload @ 7.0lbs/cu ft	67,620	84,124	84,734

suited to low density, express package operations. Moreover, most A310-200s have already been converted and are operated by FedEx. A few more are yet to be converted.

There are three MTOW options for the A310-300: 330,700lbs, 346,125lbs and 361,560lbs.

Following conversion to freighter, the A310-300F has a MZFW of 251,320lbs and OEW of 162,920lbs *(see table, this page)*. This gives the aircraft a gross structural payload of 88,400lbs *(see table, this page)*. This is only 2,000lbs less than the lowest version of the A300B4-100F, but 11,000lbs less than the A300B4-200F, the model with the highest payload.

The A310 can carry 16 88-inch wide containers on its maindeck. These each have an internal volume of 476 cubic feet and tare weight of 253lbs, taking total maindeck volume to 7,616 cubic feet and tare weight to 4,048lbs. The aircraft can also carry 14 LD-3s in its underfloor compartment. The combined internal volume of these is 2,044 cubic feet and tare weight is 3,010lbs.

The aircraft's total volume is 9,660 cubic feet and tare weight is 7,058lbs. This tare weight takes net structural payload to 81,342lbs *(see table, this page)*, about 16,000lbs less than the A300-600RF. The A310-300F's net structural payload allows a maximum packing density of 8.42lbs per cubic foot, which is the highest of all aircraft in its size class.

At a packing density of 6.5lbs per cubic foot, the A310-300F has a volumetric payload of 62,790lbs *(see table, this page)*. With a packing density of 7.0lbs per cubic foot the aircraft has a volumetric payload of 67,620lbs.

767-300SF/-300ERSF

A total of about 900 767-300s/-300ERs were built, and there are a large number of MTOW variants. The lowest MTOW is 345,000lbs, while the highest for the –300ER is 412,000lbs. The fuel capacity of 767-300s also varies, with the –300 model having a capacity of 16,700 US Gallons, and the –300ER model with a capacity of 24,140 US Gallons.

Two passenger-to-freighter conversion programmes are expected to be available for the 767-300, thOSE offered by Boeing and Aeronavali, and Bedek Aviation.

The different number of MTOW options and fuel capacities means there are also several payload-range performance versions.

Boeing 767-300SF

Boeing and Aeronavali's modification is still under development, but the –300SF aircraft will have a MZFW of 278,000lbs and OEW of 182,900lbs after conversion. The heavier –300ERSF will have a MZFW of 295,000lbs and OEW of 184,100lbs *(see table, page 44)*.

This will give the 767-300SF a gross structural payload of 95,100lbs, and the –300ERSF a gross structural payload of 110,900lbs *(see table, page 44)*.

The 767-300 will be able to accommodate 22 88-inch wide contoured containers. These each have an internal volume of 502 cubic feet and tare weight of 240lbs. In addition to these 22 containers, the maindeck can also carry two A2 containers, one at the front and one at the rear of the fuselage. These each have an internal volume of 420 cubic feet and tare weight of 240lbs. This takes total maindeck containerised volume to 11,884 cubic feet and tare weight to 5,760lbs *(see table, page 44)*.

The lower deck can carry 30 LD-2 containers. These have an internal volume of 124 cubic feet and tare weight of 203lbs, taking the total tare weight to 3,720lbs and tare weight to 6,090lbs. Total containerised volume for the aircraft is 15,604 cubic feet and container tare weight to 11,850lbs *(see table, page 44)*. This container tare weight is added to the OEW, taking net structural payload down to 83,250lbs for the –300SF and to 99,050lbs for the –300ERSF *(see table, page 44)*. This compares to a containerised volume of 13,208 cubic feet and net structural payload of 97,327lbs for the A300-600RF. Moreover, the 767-300SF's net structural payload is only

The 767-300ERSF has the high net structural payload of all medium widebody freighters. This is about 7,000lbs higher than the A300-600RF. The A300-600RF, however, is currently available at a lower market value than the 767-300ER. Moreover, modification programmes for the 767-300ER have yet been fully developed.

about 1,900lbs more than the A310-300F's *(see tables, pages 44 & 46)*. This is despite the 767-300SF having about 6,000 cubic feet greater containerised volume.

The 767-300's containerised volume is high following conversion, and the –300SF's relatively low net structural payload means it has a maximum packing density of 5.34lbs. This is the lowest of all types in this size category. This also means that the aircraft would not be able to use all its available freight volume when carrying express package freight packed at 6.5lbs per cubic foot.

The 767-300ERSF has better payload characteristics than the –300SF. The 767-300ERSF's net structural payload of 99,050lbs means it has a maximum packing density of 6.35lbs per cubic foot *(see table, page 44)*. While the aircraft's maximum packing density is low compared to the A300-600RF, the 767-300ERSF's volumetric payload is nevertheless higher. The 767-300ERSF cannot, however, utilise all its containerised volume. The 767-300ERSF has a high structural payload, but also has high containerised volume relative to its structural payload.

Bedek 767-300ERSF

Bedek's conversion of the 767-200ERSF is expected to have the same MZFW as Boeing's but a lower OEW. The OEW of 180,700lbs will thus give the aircraft a gross structural payload of 114,300lbs *(see table, page 44)*. This is 3,400lbs higher than the conversion being developed by Boeing.

Bedek's conversion will accommodate the same number of containers and pallets, and thus have identical container tare weight and internal volume as the aircraft modified by Boeing. The end result will be an aircraft with a net structural payload of 102,450lbs and maximum packing density of 6.57lbs per cubic foot *(see table, page 44)*. Volumetric payload will thus be 101,426lbs at a packing density of 6.5lbs per cubic foot, which comes to 15,500lbs more than the A300-600RF. The maximum packing density of 6.57lbs per cubic foot, however, means the volumetric payload will never be higher than 102,450lbs.

767-200SF/-200ERSF

There are 16 different MTOW variants among the 230 767-200s/-200ERs built. MTOW ranges from 279,900lbs to 395,000lbs. The most numerous aircraft have a MTOW of 351,000lbs. The 767-200 is further complicated by the number of different wing numbers, engine types and landing gear specifications. These three factors all influence potential to upgrade MTOW and MZFW during conversion.

Boeing 767-200SF

Boeing's conversion for the 767-200, which will be performed by Aeronavali, is based on most MTOW variants, although modification for aircraft with a MTOW of 360,000lbs is still under study.

Aircraft with a MTOW of up to 351,000lbs will have a MZFW of 258,000lbs and OEW of 164,600lbs, taking gross structural payload to 93,400lbs *(see table, page 46)*.

The 767-200SF will be able to accommodate 20 88-inch by 125-inch by 96-inch containers on its maindeck. Each of these has an internal volume of 420 cubic feet and tare weight of 240lbs. This will take maindeck container volume and tare weight to 9,876 cubic feet and 4,800lbs.

The lower deck will take 22 LD-2 containers, thereby providing an additional 2,728 cubic feet and tare weight of 4,466lbs. This will take total containerised volume to 12,604 cubic feet and tare weight to 9,266lbs. Resulting net structural payload will be 84,134lbs, 2,792lbs more than the A310-300F *(see table, page 46)*. The 767-200SF under this programme will have a maximum packing density of 6.68lbs per cubic foot. Volumetric payload at a packing density of 6.5lbs per cubic foot would thus be 81,926lbs, and be limited to 84,134lbs for higher packing densities *(see table, page 46)*.

The aircraft with a MTOW of 360,000lbs would have a MZFW of 266,000lbs and gross structural payload of 101,400lbs. This would be 8,000lbs higher than the aircraft currently offered. This higher payload would in turn allow a higher packing density of 7.31lbs per cubic foot.

Bedek 767-200SF

Bedek's 767-200SF modification is based on an aircraft with a MTOW of 351,000lbs. This will have the same MZFW as the Boeing modification of 258,000lbs. Bedek's aircraft will have a slightly lower OEW of 164,000lbs,

PAYLOAD CHARACTERISTICS A310-300F & 767-200SF

Aircraft type	EADS-EFW A300-600RF	Boeing 767-300ERSF	Bedek 767-300ERSF	EADS-EFW A310-300F	Boeing 767-200ERSF	Bedek 767-200SF
Volumetric payload @6.5lbs/cu ft 90% load factor	77,267	89,145	92,205	56,511	73,733	73,733
Revenue generated @ $1.00/lb	$77,267	$89,145	$92,205	$56,511	$73,733	$73,733
Volumetric payload @ 7.0lbs/cu ft 90% load factor	83,210	89,145	92,205	60,858	75,712	76,261
Revenue generated @ $0.40/lb	$33,284	$35,658	$36,882	$24,343	$30,285	$30,504
Revenue generated @ $0.80/lb	$ 66,568	$ 71,316	$ 73,764	$ 48,686	$ 60,570	$ 61,009

providing a gross structural payload of 94,000lbs *(see table, page 46)*.

The aircraft will accommodate the same number of maindeck and lowerdeck containers, providing 12,604 cubic feet of containerised volume and 9,266lbs of tare weight. This will take net structural payload to 84,734lbs and maximum packing density to 6.72lbs per cubic foot *(see table, page 46)*. This will result in almost identical volumetric payloads as the Boeing converted 767-200SF at the same packing densities *(see table, page 46)*.

Payload summary

The net structural and volumetric payloads so far analysed are in conditions where the aircraft do not face any gross payload restrictions due to operational factors such as limited MTOW or sector length.

In the case of the larger aircraft, the 767-300SF has the lowest net structural payload, which is about 14,000lbs less than the A300-600RF's.

The 767-300ERSF, however, has about a 1,700lbs advantage over the A300-600RF. The Bedek-converted 767-300ERSF has an even larger advantage of about 5,000lbs, due to a similar OEW but higher MZFW than the A300-600RF.

Despite these small gross payload advantages, the 767-300 has 2,400 more cubic feet of containerised capacity (equal to 18%) than the A300-600RF. While a higher containerised volume and structural payload may appear to give the 767-300 an overall advantage, the A300-600RF does have a higher maximum packing density. The 767-300's packing density is limited because of its high containerised volume in relation to its structural payload. Overall, however, the 767-300ERSF has the highest volumetric payload at a variety of densities.

In the case of the smaller aircraft, the A310-300F has a 2,792lbs smaller structural payload than the 767-200ERSF. The A310-300F's bigger disadvantage, however, is that it has a 25% lower containerised capacity. The A310-300F's volume is thus low in relation to its structural payload, which gives it a high maximum packing density. The 767-200ERSF, however, has a 19,100lbs higher volumetric payload than the A310-300F when packed at 6.5lbs per cubic foot *(see table, page 46)*. This difference is directly proportional to its lower containerised volume.

Freight revenue

While few freight aircraft operate at a 100% load factor, few freight airlines can afford to operate them with moderate load factors. The revenue generating capacity of the aircraft should thus be examined at relatively high load factors in the region of 90%.

Express package operations typically have freight packed at a density of 6.5lbs per cubic foot. The volumetric payloads of the different aircraft options at this load factor are shown *(see table, this page)*. Revenues generated by small package integrators are reported for total transit, and not just the air carriage portion. Yields are estimated, however, to be in the region of $1 per lb, which gives an indication of the aircraft's approximate and relative revenue earning power. Moreover, it indicates how its revenue generating capacity compares to its competitors.

The aircraft with the highest capacity will naturally have the highest revenue generating ability. The 767-300ERSF therefore is the clear winner. Actual capacity will depend, however, on the MTOW variant and what the OEW and MZFW are following conversion. While the A300-600RF has the second largest capacity, the 767-200SF is close behind. The 767-200SF does, after all, have only a 600 cubic feet smaller capacity than the A300-600RF. The A310-300F has the smallest, and its capacity is similar to the 757-200SF's when carrying freight packed at this density *(see Revenue earning capacity of the 737-300 & 757-200SF, Aircraft Commerce, February/March 2004, page 42)*.

The order of volumetric capacity at a packing density of 7.0lbs per cubic foot and load factor of 90% when carrying general freight is the same as for express packages at a lower density. That is, the 767-300SF has the highest payload, followed by the A300-600RF, 767-200SF and then the A310-300F.

A typical net yield for general freight is in the region of $0.40 per lb, although in some markets it can be as high as $0.80 per lb. The revenue generating capacity of the six aircraft options is thus shown for these two yields.

At the lower yield the differences between the aircraft are naturally less pronounced. The A300-600RF, for example, has a $3,600 lower revenue generating capacity than the 767-300ER, while the A310-300F has about a $6,000 lower capacity than the 767-200SF *(see table, this page)*. Although these differences are relatively small when yields are higher, they are not small enough for them to be made up with differences in operating costs between the two aircraft. Trip costs of fuel, maintenance, flight crew, insurance, lease rentals and handling charges for a 2,500nm sector are in the order of $25,000 for both an A310-300F and 767-200SF, and $28,000-29,000 for the A300-600RF and 767-300SF. AC