Several conversion programmes have been developed for the 737-300SF & 757-200SF, and each has different payload characteristics. Payload capacities have to be considered in relation to freight packing densities, rates received for freight and the revenue that can be generated.

Revenue earning capacity of the 737-300 & 757-200SF

The operating costs of the 737-300SF and 757-200SF with monthly lease rentals of $150,000 and $200,000 provide them with a unit cost per lb of available payload that is similar or better than the cost per lb of available payload of the 727-200F with a lease rate of $50,000 per month on a 700nm trip *(see The options for 727F replacement, Aircraft Commerce, February/March 2003, page 46).* This is a typical sector length for express package operations. The trip costs including fuel, maintenance, engine inventory, insurance, flightcrew and lease rentals for a 737-300SF and 757-200SF are in the region of $7,000 and $9,000.

Trip costs for general freight operations with sectors of 1,500-2,000nm will be about $13,000-19,000 for the 737-300 and $17,000-25,000 for the 757-200SF.

The economic case for acquiring the 737-300SF and 757-200SF relies on their revenue generating ability.

Economic principles

Most freight aircraft are only economic when all available freight capacity is utilised. This is because revenues per unit of available payload on freighters are small. Freight carriers rarely have to concern themselves with the problem of 'spill', however, and can thus operate at high average load factors.

Freight operators have to be concerned about the gross profit performance capability of their aircraft. Trip costs are virtually constant with increasing payload while revenue increases proportionately. An aircraft will be most economic where freight volume is close to its maximum capacity. Small differences in payload capacity and revenue make a difference in economic performance.

Types of freight

The values of passenger-configured 737-300s and 757-200s are low enough for the total cost of making the 737-300 and 757-200SF available for service at attractive lease rates. There are several markets they could operate in, each with its own characteristics and economic conditions.

The largest is the express freight market, where several hundred 727-100Fs/-200Fs operate for several airlines in the US, Latin America, Europe, the Indian sub-continent, Africa, the Middle East and Asia Pacific. There are several other aircraft types that could be replaced by the 737-300 and 757-200SF.

The other major market is the general freight market, which extends to most parts of the globe.

While express freight is similar for all global regions, general freight is diversified, and the types of freight reflect the region of operation. General freight includes manufactured goods (often electronic items), industrial equipment, and agricultural products, such as fruit,

Airlines have choices in the type of containers they select for their aircraft. While containers can have the same dimensions they can have different weights and so affect the net structural payload of the aircraft and thus its revenue generating capacity. Other important factors in net structural payload are an aircraft's MZFW and OEW.

flowers and fish.

Airlines operating in the Latin American market, for example, mainly carry fruit, while fish accounts for the majority of freight for airlines in Iceland. Manufactured goods account for much of the general freight carried by airlines in the Asia Pacific.

Petur Eiriksson, managing director of Icelandair Cargo explains that the belly capacity of passenger airline aircraft is made available for transporting general freight at low rates. "This availability of freight capacity brings down general freight, but especially in short-haul markets served by a lot of airlines. There are therefore few general freight airlines operating US domestic networks where there is a high volume of passenger flights. There are some general freight airlines between Europe and Africa, for example, where there are less passenger services. This is why only express package freight airlines operate within the US and Europe. The yields for express packages allow the costs of operation to be covered."

The importance of freight type relates to the packing densities, and in turn the payload that can be carried by the aircraft. Freight aircraft have both a structural payload capacity, of maximum zero fuel weight (MZFW) minus operating weight (OEW) and tare weight of freight containers or pallets; as well as a volumetric capacity allowed by the containers or pallets. Maximum packing density of the aircraft in lbs per cubic foot is the net structural payload divided by available volume.

Any type of freight packed into containers or onto pallets at a density lower than maximum packing density will fill the aircraft before all structural payload is utilised, thus 'bulking out' the aircraft. Freight with a density higher than maximum packing density will utilise the aircraft's structural payload before all available volume is filled, thus 'grossing out' the aircraft.

The weight of payload carried in an aircraft depends on its packing density. Freight is charged in rates per lb, but different types of freight have different rates per lb, and rates also vary with several market conditions.

Besides actual weight of freight carried, rates for freight can be charged on a 'dimensional' weight basis. This is where some large items have physical dimensions that take up a section of the aircraft that could otherwise be used by containers of pallets. The dimensional weight would be the weight that could be carried in those container or pallet positions. Carlos Gamundi, network general manager of DHL Aviation Americas explains that if the shipment weighs more than its dimensional weight, then the physical weight is charged. Dimensional weight is charged if it is higher than the physical weight.

The revenue earning capacity of the 737-300SF/-400SF and 757-200SF can therefore vary widely. The actual weight that can be carried by each aircraft type for freight of different packing densities has to be analysed.

Express mail has packing density in the region of 6.5 lbs per cubic foot, while general freight will be 7-8lbs per cubic foot.

737 & 757 freighter capacity

There are now several passenger-to-freighter modifications for the 737-300 and 757-200. Each conversion programme for the same type varies and has different structural payloads and containerised volumes. The 737 and 757 both have the advantage of having the same fuselage cross-section as the 727-100/-200 (and DC-8 series), and can use the standard 82-inch high X 88-inch X 125-inch maindeck containers. These are contoured to fit the inside of the fuselage, maximising use of the aircraft's interior volume. These can be made from a variety of different materials and so have different weights. For aircraft to be analysed on a consistent basis a tare

weight of 476lbs and internal volume of 440 cubic feet is used for each standard container.

The two main modifications for the 737-300 are from Pemco, Alabama and Bedek Aviation, Israel. Both companies say they could develop supplemental type certificates (STCs) for the 737-400 relatively easily, since the modification would have little difference with the -300's STC. Bedek Aviation is in discussions with prospective customers for the 737-400, and the first aircraft could be converted by the end of 2004 and delivered in early 2005.

In both cases, the 737-300SF has space for eight standard containers on its maindeck plus a smaller ninth container.

The two main non-original manufacturer passenger-to-freighter conversions for the 757-200 are offered by Precision Conversions and Alcoa-SIE. Neither company yet has an STC for its modification, although Precision has its first aircraft undergoing conversion at Goodrich's Everett plant, Washington, with completion expected in mid-2004. Alcoa-SIE meanwhile is developing the engineering for its STC and is in the process of acquiring its first aircraft to convert.

The Precision Conversions modification allows 15 standard containers on its maindeck, while Alcoa-SIE is developing a programme for 14 plus a smaller container.

Bedek Aviation is in discussions with Boeing and Singapore Technologies to work on Boeing's STC for a 14-and-a-half container conversion for the 757-200 to increase capacity to a full 15 container modification. The target is also to lower cost of conversion by 25-30%.

Pemco 737-300SF

Pemco offers two types of modification for the 737-300; quick change and full-freighter modification. The full freighter modification is analysed here.

The converted aircraft will have a MZFW of 109,600lbs *(see table, page 46)*. OEW is dependent on weight for crew, water and food, and an allowance of 500lbs is given for this. OEW varies with conversion, and the average weight of 68,298lbs is taken. This gives the aircraft a gross structural payload of 40,802lbs.

The maindeck has capacity for eight standard containers and a smaller ninth container, with an internal volume of 152 cubic feet and tare weight of 230lbs.

Total maindeck volume is thus 3,672 cubic feet. These nine containers have a combined tare weight of 4,038lbs. This takes the net structural payload to 36,764lbs *(see table, page 46)*. This has to be considered against the maximum allowable load for each container position.

The aircraft also has 1,068 cubic feet of space below the maindeck, taking total freight volume to 4,740 cubic feet *(see table, page 46)*. The aircraft can thus have a maximum packing density of 7.7lbs per cubic foot. If filled with freight at this density each of the main eight containers would have a total floor weight of 3,864lbs.

The maximum floor weight of the first three positions is 5,700lbs each, the fourth and fifth 9,200lbs each, and the sixth, seventh and eighth 5,000lbs each. All container positions could thus be filled at maximum packing density without exceeding floor weight limits. The smaller ninth container has a maximum floor limit of 3,500lbs. Filled at maximum packing density it would have a gross weight of 1,550lbs.

The aircraft will have a maximum volumetric payload of 30,810lbs if the total volume of 4,740 cubic feet is filled with express packages packed at 6.5lbs per cubic foot.

General freight packed at 7.0lbs per cubic foot would generate a volumetric payload of 33,180lbs.

General freight packed at 7.7lbs per cubic foot would generate a volumetric

PAYLOAD CHARACTERISTICS 737-300SF & 757-200SF

Aircraft type	Pemco 737-300SF	Bedek 737-300SF	Precision 757-200SF	Alcoa-SIE 757-200SF
MZFW-lbs	109,600	109,600	184,000-188,000	184,000
OEW-lbs	68,298	66,000	114,000-117,000	118,000
Gross structural payload-lbs	41,302	43,600	67,000-74,000	66,000
Crew weight-lbs	500	500	500	500
Number maindeck containers	8 +1	8 + 1	15	14 + 1
Type maindeck containers	82/88/125	82/88/125	82/88/125	82/88/125
Unit tare weight maindeck containers-lbs	476/230	476/230	476	476
Unit volume maindeck containers-cu ft	440/152	440/152	440	440/380
Total tare weight maindeck containers-lbs	4,038	4,038	7,140	7,140
Total volume maindeck containers-cu ft	3,672	3,672	6,600	6,540
Lowerdeck volume-cu ft	1,068	1,068	1,790	1,790
Net structural payload-lbs	36,764	39,562	59,360-66,360	58,360
Total volume-cu ft	4,740	4,740	8,390	8,330
Maximum packing density-lbs/cu ft	7.72	8.3	7.08-7.92	7.0
Volumetric payload @ 6.5lbs/cu ft	30,810	30,810	54,535	54,145
Volumetric payload @ 7.0lbs/cu ft	33,180	33,180	58,730	58,310
Volumetric payload @ 7.7lbs/cu ft	36,498			
Volumetric payload @ 7.9lbs/cu ft	N/A		66,280	N/A
Volumetric payload @ 8.0lbs/cu ft	N/A	37,920	N/A	N/A

payload of 36,498lbs (the aircraft's maximum).

Bedek 737-300SF

With modification by Bedek, the 737-300SF will have a MZFW of 109,600lbs and a target OEW ready for service (including crew weight) of 66,000lbs. The gross structural payload would thus be 43,600lbs *(see table, this page)*.

Like the Pemco modification, the aircraft can accommodate eight standard containers and a smaller ninth container could also be carried, which would provide an internal volume of 152 cubic feet and tare weight of 230lbs. Maindeck containerised volume would thus be 3,672 cubic feet and tare weight 4,038lbs. This takes net structural payload to 39,562lbs *(see table, this page)*. The aircraft also has a lower deck volume of 1,068 cubic feet, taking total volume to 4,740 cubic feet. This allows a maximum packing density of 8.3lbs per cubic foot.

The floor weight allowances for the first, second and third container is 5,600lbs each, for the fourth container 9,000lbs, for the fifth container 7,250lbs, for the sixth and seventh container 5,000lbs each, for the eight container 4,700lbs each and for the smaller ninth container 2,000lbs each. At a maximum packing density of 8.3lbs the first eight containers will have a gross weight of 4,128lbs. These can thus be filled at maximum packing density without floor weights being exceeded. The ninth container would have a gross weight of 1,511lbs, and so would also not exceed floor weight limits.

With freight packed at 6.5lbs per cubic foot, the aircraft has a volumetric payload of 30,810lbs. A higher density of 7.0lbs per cubic foot takes volumetric payload to 33,180lbs and a density of 8.0lbs per cubic foot equals a volumetric payload of 37,920lbs *(see table, this page)*.

Precision 757-200SF

As with all converted aircraft, the MZFW of the 757-200SF modified by Precision Conversions varies according to the original aircraft configuration, structural capability and certified operating weights. The range Precision Conversions expects is 184,000-188,000lbs. The OEW will be between 114,000lbs and 117,000lbs *(see table, this page)*. The aircraft's gross structural payload will thus be 67,000-74,000lbs. Some 757s are also compatible for weight increases that are optional under the modification programme.

The aircraft can accommodate 15 standard maindeck containers. These each have an internal volume of 440 cubic feet and tare weight of 476lbs. This provides a total maindeck volume of 6,600 cubic feet *(see table, this page)* and container weight of 7,140lbs. With a further 500lbs being allowed for crew weight, the aircraft would have a net structural payload of 59,360-66,360lbs, depending on the MZFW and OEW of the converted aircraft. The aircraft also has a lower deck volume of 1,790 cubic feet, taking total available volume to 8,390 cubic feet, and allowing a maximum packing density of 7.08-7.92lbs per cubic foot *(see table, this page)*. The gross weight of each of the 15 containers with freight packed at maximum density would thus be 3,585-3,955lbs.

The maximum allowable floor weights for the maindeck containers are 6,200lbs each for the first seven, 9,400lbs each for the eighth and ninth, 5,700lbs for the 10th, 5,500lbs each for the 11th and 12th, and 5,400lbs each for the 13th, 14th and 15th. These allowances would thus allow a higher packing density in the maindeck containers without the operator having to use the underfloor space, provided the actual freight being carried could be packed at a higher density.

With express freight packed at 6.5lbs per cubic foot, the aircraft will have a volumetric payload of 54,535lbs.

Volumetric payload at a density of 7.0lbs per cubic foot would be 58,730lbs, and volumetric payload at a packing density of 7.9lbs would be 66,280lbs, equal to the maximum net structural payload. This higher volumetric payload is, however, dependent on the higher structural payload of 74,000lbs being available after conversion.

Alcoa-SIE 757-200SF

Alcoa-SIE's targets for MZFW and OEW of its 757-200SF modification are close to those of Precision Conversions' weights. MZFW will be 184,000lbs and OEW is targeted at 118,000lbs. This will allow a gross structural payload of 66,000lbs *(see table, this page)*. Alcoa-SIE's modification will have capacity for 14 standard containers plus a smaller 15th 61.5-inch X 60.4-inch smaller container. The internal volume of the

VOLUMETRIC PAYLOAD @ 90% LOAD FACTOR & REVENUE GENERATED FOR VARYING NET FREIGHT YIELDS

Aircraft type	Pemco 737-300SF	Bedek 737-300SF	Precision 757-200SF	Alcoa-SIE 757-200SF
Volumetric payload @ 6.5lbs/cu ft @ 90% load factor	27,729lbs	27,729lbs	49,081lbs	48,730lbs
Revenue generated @ $1.00/lb	$27,729	$27,729	$49,081	$48,730
Volumetric payload @ 7.0lbs/cu ft @ 90% load factor	29,862lbs	29,862lbs	52,857lbs	52,479lbs
Revenue generated @ $0.40/lb	$11,945	$11,945	$21,143	$20,992
Revenue generated @ $0.50/lb	$14,931	$14,931	$26,429	$26,240
Revenue generated @ $0.60/lb	$17,917	$17,917	$31,714	$31,487
Volumetric payload @ 7.7lbs/cu ft @ 90% load factor	32,847lbs			
Volumetric payload @ 7.7lbs/cu ft @ 90% load factor			59,652lbs	
Volumetric payload @ 8.0lbs/cu ft @ 90% load factor	N/A	34,128lbs	N/A	N/A
Revenue generated @ $0.40/lb	$13,139	$13,651	$23,861	N/A
Revenue generated @ $0.50/lb	$16,424	$17,064	$29,826	N/A
Revenue generated @ $0.60/lb	$19,708	$20,477	$35,791	N/A

15th container will be 380 cubic feet. The total container volume on the maindeck will thus be 6,540 cubic feet; only 60 cubic feet less than the Precision Conversions aircraft. Tare weight of all maindeck containers will total 7,140lbs. A further 500lbs for crew will take net structural payload to 58,360lbs *(see table, page 46)*. Lower deck volume will provide another 1,790 cubic feet, taking total to 8,330 cubic feet. This will allow a maximum packing density of 7.0lbs per cubic foot. Freight at this density will take gross weight of each maindeck container to 3,550lbs. The 15th container will have a gross weight of 3,136lbs.

The floor weight allowance of the first is 4,149lbs, the second to the sixth 8,000lbs each, the seventh and eighth 11,000lbs each, the ninth and 10th 7,500lbs each, the 11th 7,315lbs, the 12th 7,015lbs, the 13th 6,715lbs, and the 14th 6,415lbs. The 15th container has a maximum floor weight of 3,000lbs, just 136lbs less than that allowed by the maximum packing density. The high floor weight allowances for each container make it possible to pack freight at a higher density than 7.0lbs per cubic foot in the maindeck containers, which would avoid the underfloor space being used.

Freight packed at 6.5lbs per cubic foot would generate a volumetric payload of 54,145lbs *(see table, page 46)*, and freight at 7.0lbs per cubic foot would give the aircraft a volumetric payload of 58,310lbs; the highest possible in the aircraft.

Traffic volumes

The volumetric payload data shown are the maximum possible for specific packing densities. Actual payloads carried, however, will be less than 100% load factor in many cases.

Express package airlines work on a hub-and-spoke system, and express packages do travel in both directions, so do not face the problem of directional imbalance.

General freight, however, is uni-directional and so load factors can vary. Most freight carriers will operate with load factors that consistently reach 90% or more before upgrading to larger aircraft.

To analyse the revenue earning capacity of the four aircraft types the payload has been analysed based on a 90% load factor.

Freight yields

Rates received by airlines per lb of freight vary with type of freight and direction. Express packages have the highest rates per lb of all types of freight because of their time sensitivity. They also have the advantage of being bi-directional. Express package rates per lb also vary less with global region than do rates for general freight. This is because express package rates are related to the fact that packages are time-sensitive.

Gamundi estimates that airlines might receive rates of about $1 per lb for priority parcels and express packages. Actual rates for air freight are hard to determine, since customers pay a total price which includes door collection and delivery, ground transportation, sorting and transport by aircraft. The element that is allocated to the air transport part of the shipment is not calculated separately. Also, integrators such as FedEx and UPS do not charge different rates for different route lengths, but conversely charge flat rates for shipments in different global regions based on the weight of the package. That is, FedEx, for example, will have different standard rates for packages up to 1/2lb for US domestic, transatlantic, trans-Pacific and several other global regions. The revenue received for sending a 1/2lb package between Dallas and Chicago will be the same as between New York and Los Angeles.

Integrators have a system of a fixed price for envelopes with a weight of up to 1/2lb. Fixed price means revenue per lb received will vary with the weight of the envelope, but the average packing density of these envelopes means that it will be fairly consistent with aircraft payload. FedEx's rates for overnight envelopes weighing less than 1/2lb are in the region of $10, with international priority rates being much higher.

Large items are carried in boxes, which are charged at a higher price, but generate a lower rate per lb. Typical boxes weigh in the region of 5lbs; FedEx charges $15-25 for these, thus receiving $3-4 per lb in total revenue.

Allocating an element of revenue received per lb for the air transport part of an express package shipment can be taken as a flat rate of $1 per lb, although this is arbitrary since the objective is to cover all costs and maximise efficiency. This leaves the remainder of the revenue received to cover all other costs. Express package airlines will have higher costs for package sorting, handling and loading than general freight does.

As described, there are various types of general freight, all with varying rates per lb. Rates also vary with the different markets. Express packages can get four times the rate per lb that perishables receive. Gamundi also explains that rates for general freight are affected by directional flow. "High demand in one

The 757-200SF will have about 30% higher trip costs than the 737-300SF on 700-2,000nm sectors, but the 757-200SF will have a 65-80% higher payload capacity. Airlines have to take into consideration handling costs as well as aircraft trip costs, overheads and unit revenues per lb of freight when analysing potential gross profit performance of different aircraft types.

direction can increase rates while low demand in the opposite can reduce them. For example, rates from the US to Brazil can be as high as $1 per lb, while they would be as low as $0.60 per lb going the other way. Even larger differences can exist where there is greater directional imbalance. Where volumes might use 90% of aircraft capacity and have a rate of $1 per lb, volume in the other direction might only use 45% of aircraft capacity and attract a similarly lower rate of, for example, $0.50 per lb. Revenue generated in the weak direction would thus only be one quarter of the revenue generated in the opposite direction. Freight carriers thus have to consider the average revenue that can be generated by the aircraft from both directions when assessing a route's viability.

Net general freight rates also vary with global regions. Eiriksson estimates the US domestic and trans-European markets to have average rates of $0.15-0.25 per lb, which is too low for a general freight operation to be viable there. "Rates also do not vary much with sector length but are rather determined by market forces. What has to be remembered is that handling at either end can cost about $0.06-0.10 per lb, and so a net rate of $0.10-0.15 per lb would be received in these markets." This would generate a total of about $3,300-4,900 per 737-300 operating 90% full, irrespective of sector length it would not be enough to cover aircraft trip costs.

Eiriksson makes the point that this is the reason that general freight operations are seen outside the US and Europe. "Rates provided by passenger airlines in these areas are $0.15-0.30 per lb, and this undermines the freight carriers."

Eiriksson adds that general freight rates are higher in other parts of the world, citing Iceland to Europe and Iceland to the US as examples, with rates of about $0.40-0.45 per lb and $0.55-0.60 per lb. These are for longer routes and aircraft trip costs and handling charges have to be considered. Handling costs of $0.15 per lb would reduce these rates to about $0.30 per lb and $0.45 per lb. "Rates for carrying perishables in the Europe-Africa market are generally higher, at about $0.60 per lb, but there is the problem of directional imbalance."

Gamundi estimates the US-Latin American market to have average rates of $0.4-0.6 per lb, the intra-Latin American market to have rates of $0.20-0.75 per lb, the Europe-Africa/Middle East market to have rates of $0.50-0.75 per lb, the intra-European market to have rates of $0.25-0.40 per lb and the intra-Asian market to have rates of $0.40-0.50 per lb. These are all areas where the 737-300SF and 757-200SF could be employed to haul general freight.

The range for general freight rates could thus be as wide as $0.25 to $0.75 per lb, depending on the direction of travel on the route and the type of freight.

A net general freight at a rate of $0.40 per lb would generate a total revenue of about $11,945 for a 737-300 operated at a load factor of 90% for freight with a density of 7.0lbs per cubic foot. This would only cover trip costs including fuel, maintenance, flightcrew, aircraft lease rate, engine inventory and insurance on a sector of up to 1,100nm. Higher rates would thus be required to cover handling charges and other airline costs. A rate of $0.50 per lb would generate about $15,000 of revenue.

Aircraft revenue

The potential revenue generated by each aircraft carrying general freight at packing densities of 7.0lbs and 8.0lbs per cubic foot at rates of $0.40, $0.50 and $0.60 per lb for aircraft operated at 90% load factor is shown *(see table, page 47)*. The table thus shows the maximum revenue each aircraft can generate when carrying freight at these different rates.

These revenues must be considered against the basic aircraft trip costs of fuel, maintenance, engine inventory, flightcrew, insurance and lease rentals and many other charges too. These start with user fees for navigation and landing charges, as well as costs of freight loaders and freight handling charges. Mauricio Londono, vice president of operations and maintenance at Tampa Cargo Airlines explains that airlines also have to pay security charges for freight and in recent months have added a surcharge for high fuel prices.

The revenues generated are the highest possible for the respective net rates. These have to be considered against aircraft trip costs. These general freight rates are representative of the current market, which has experienced low rates for the past three to four years. Eiriksson estimates that rates in many markets are 50% lower than they were in 2000 and 2001, because of a combination of low traffic volumes and an increase in the availability of belly space due to the growth in the passenger fleet.

A 737-300 operating a 1,500nm sector will have a trip cost for fuel, maintenance, flightcrew and lease rentals in the region of $13,000. If operated at a load factor of 90% and carrying about 29,000lbs, it would still need to have a net rate of about $0.65 per lb to cover trip and handling costs.

A 757-200SF operating a route of the same length would have marginally higher trip costs of about $17,000. It would need a net rate of about $0.45-0.50 per lb to cover trip and handling costs, illustrating the advantage of the economies of scale offered by a larger aircraft; such as the 757-200, which has 77% more capacity than the 737-300. This is only realised, however, if all the 757-200's available payload is utilised. AC