As fuel prices rise and older freighters continue to age, freight carriers operating at low rates of utilisation will have to consider their options for fleet renewal. There are now five main narrowbody types for them to consider. Their economics are assessed here.

Narrowbody freighter selection for low utilisation operations

Operating freighters at low rates of utilisation has always been economically challenging. Freight operations have always required high load factors and freight yields, as well as the lowest possible aircraft capital costs. Low cash-operating costs took a low priority, but with fuel prices at continually high levels, fuel-burn efficiency has become more important relative to capital cost. Express-package, courier and postal operations account for most low utilisation operations, but there are also some general freight carriers operating at low rates of utilisation. There are many aircraft types and a larger number of aircraft type combinations that operators can select.

Low utilisation markets

Low utilisation markets are mainly based around express-package and postal operations, with aircraft flying at night. The largest market is clearly the US, with FedEx and UPS both operating large domestic fleets of 727s and 757PFs, together with several widebody types. FedEx has chosen to replace its 727Fs with the 757SF.

FedEx and UPS operate a hub-and-spoke type of operation. It is usual for most routes to be flown once per night with a return service, and usually six or seven days per week. Most aircraft therefore only accumulate up to 730 flight cycles (FC) per year. Narrowbodies are usually operated on shorter sectors of 400-600nm, so aircraft accumulate 900-1,200FH per year in most cases.

Both carriers have mixed fleets of converted and factory-built freighters, although UPS has a higher portion of new aircraft, and both operate their aircraft up to a high age. This is necessary given that annual utilisations for their 727Fs and 757PFs are 900-1,200FH.

While there has been consolidation among other US express-package carriers, Astar Air Cargo operates air services for DHL Worldwide Express. Astar operates seven 727-200Fs, and has retired larger numbers of the type in recent years.

ABX Air operates some express-package services, and its active narrowbody fleet comprises 33 DC-9-30Fs and -40Fs.

Other smaller airlines include Amerijet and Capital Cargo.

Express-package services have spread to Canada, South & Central America, Europe, the Middle East and the Asia Pacific.

Canadian freight carriers operating narrowbody fleets at low rates of utilisation include Kelowna, Cargojet and Morningstar Air Cargo. Kelowna operates a Canadian domestic network of overnight operations. "We operate across the country, and because of the route lengths and time zones, aircraft can only operate at low rates of utilisation for packages to be delivered by the next day. Our 14 727-200s average about 820FH per year," says Barry Lapointe, chief executive officer of Kelowna Flightcraft.

Several express-package air services are operated in Central and South America. DHL Aero Expreso operates four 727-200Fs, and DHL de Guatemala and DHL Ecuador each operate a single ATR42 freighter all for DHL.

Estafeta Carga Aerea is an established small- and express-package carrier in Mexico, with a fleet of 737-200Fs and -300Fs.

Regional Cargo is a new operator in Mexico that operates domestic air-freight services on behalf of the US express-package companies DHL and FedEx. It also carries freight for Mexican and international passenger airlines. "We started with a small operation using a single 737-200F, and will be adding a second 737. We plan to have a fleet of five 737 freighters by the end of 2010," says Juan Rodriguez Anza, director general at Regional Cargo.

The largest European airlines with narrowbodies are DHL Air, European Air Transport (EAT), TNT Airways, Bluebird Cargo, Swiftair and Europe Airpost.

Express-package air services have also spread to the Middle East and Asia Pacific.

DHL Aviation in Bahrain operates five 727-200Fs for DHL Express.

In India, Blue Dart Aviation operates with a fleet of 737-200s and 757-200s. There is a group of three airlines in the Asia Pacific operating scheduled and charter services for express packages and postal items: Transmile Air Service of Malaysia; K-Mile Air of Thailand; and PT Megantara Air of Indonesia. Transmile has a fleet of nine 727-200Fs and three 737-300Fs. K-Mile and Megantara each have two 727-200Fs. "We operate at night on hub-and-spoke and direct services, but much less during the day when the large passenger aircraft with belly capacity are flying," explains Robert Hyslop, chief operations officer at Transmile Air Services.

Several airlines operate narrowbodies in Australia. One is Australian Air Express, which operates 727-200Fs and 737-300Fs.

Freighter operations

Most low utilisation operations are air services for express and courier packages. These are based on delivering packages within a guaranteed timeframe, usually within 24 hours. Air services therefore do not need to operate at high frequencies, since next-day delivery of packages means that aircraft can operate at night, many within a hub-and-spoke route network. Packages are transferred between flights at the hub so they arrive at their destination the following morning. Most airlines therefore only need to operate their aircraft on one return flight via the hub per night. There

NARROWBODY FREIGHTER: PAYLOAD SPECIFICATIONS FOR PACKAGE OPERATIONS

Aircraft type	BAE 146 -300QT	737-200F	737-300F	737-400F	A320F
MZFW-lbs	80,500	95,000	106,000-109,600	113,000-117,000	134,505/137,812
OEW-lbs	51,257	60,000	62,000-67,300	68,000-70,200	87,979
Gross structural payload-lbs	29,243	35,000	42,300-44,000	45,000-47,600	46,526/49,833
Maindeck containers	6 x 88/108 plus demi	7 x 88/125 plus 1 88/108	8 or 9 x 88/125	9 or 10 x 88/125	10 x AAY
Container tare-lbs	2,646	3,332	4,038/4,284	4,284/4,760	4,240
Container volume-cu ft	2,440	3,432	3,520-3,960	4,310/4,400	4,400
Underfloor capacity-cu ft	812	875	1,068	1,373	
Underfloor containers					7 x LD3-45W
Container tare-lbs					1,267
Container volume-cu ft					889
Total container tare-lbs	2,646	3,332	4,038/4,284	4,284/4,760	5,507
Total capacity-cu ft	3,252	4,307	4,588/5,352	5,683/5,773	5,289
Net structural payload-lbs	26,597	31,668	38,262-39,716	39,500-42,840	41,019/44,326
Volumetric payload @ 7lbs/cu ft	22,764	30,149	32,116/37,464	39,781/40,000	37,023

is enough time for packages to be sorted from incoming flights and re-loaded for outgoing services and still be delivered on time.

Aircraft can typically achieve 600-700 flight cycles (FCs) per year. This is similar to the number of annual FC accumulated by most of the express-package operators that utilise the 727-200F, various 737F types, and various 757-200F models.

The number of FH accumulated each year is determined by the average route length and so flight time. In most cases the 727-200F, various 737F models, and various 757-200F models operate at average flight times of 1.25-1.75FH, depending on their route network. This is equal to routes of 350-550nm. Some airlines have shorter and longer average stage lengths.

FedEx, for example, still operates 75 727-200Fs with an average annual utilisation of 855FH and 670FC, which is an average FC time of 1.27FH. Although it has factory-built 757PFs, UPS operates on a similar basis and its aircraft accumulate 1,200FH and 770FC per year, an average FC time of 1.57FH.

Other examples of 727-200F operations are: Astar Air Cargo, which has annual utilisations of 1,390FH and 710FC and an FH:FC ratio of 1.95FH; Cargojet Airways, which operates at 905FH and 535FC per year, and has an FH:FC ratio of 1.70FH; Kelowna Flightcraft, which operates its 727-200Fs at 818FH and 570FC, an average FC time of 1.44FH; and Transmile Air Service of Malaysia, which achieves one of the highest rates of utilisation, at 1,590FH and 734FC per year, and an average FC time of 2.17FH.

Utilisations of all major 727-200F operations are 850-1,700FH and 570-1,343FC per year, and average FC times are 1.00-2.17FH. Most operations have average FC times of 1.25-1.75FH, equal to stage lengths of 400-600nm.

These rates of utilisation are in contrast to those achieved by younger types, including the 737-300F and 757-200F. The lowest utilisations for the 737-300F, for example, are by Bluebird Cargo of Iceland, which accumulates 1,370FH and 817FH per year, at an average FC time of 1.67FH. All other major 737-300F operators achieve 1,800-2,100FH and 1,100-1,475FC per year at FC times of 1.30-1.90FH per FC.

TNT Airways, which operates express-package services from its hub at Liege, Belgium to more than 70 European destinations, has a fleet of 13 BAE146QT freighters and eight 737-300Fs. The BAE146QTs have an average FC time of 1.29FH, while the 737-300Fs operate on longer average routes of 1.68FH. Both fleets are operated more intensively than traditional express-package air services, and the BAE146QTs accumulate about 1,200FH and 940FC per year. The 737-300Fs are used more intensively, at 1,090FC per year, equal to about three FCs per day, and 1,820FH per year.

The range of FC times for all 737-300F operations is similar to the 727-200F fleet, indicating that both are operated on route networks with similar route lengths.

Similarly, where 757-200Fs are operated for express-package and courier air services, some are used at higher rates of utilisation than traditional levels seen for 727-200Fs.

Blue Dart Aviation has a route network than spans India. The aircraft achieve about 1,600FH and 940FC per year. Capital Cargo, which has recently taken delivery of two 757-200PCFs, accumulates about 2,600FH and 1,160FC per year at an average FC time of 2.25FH. Its FH utilisation is therefore more than double what it achieves with its 727-200Fs.

FedEx, which selected the 757-200SF as its 727-200F replacement, has operated the 757 at more than 3,000FH and 1,200FC per year - about four times the level of utilisation of its 727-200Fs.

DHL Air of the UK and European Air Transport (EAT) operate the oldest fleets of converted 757-200Fs for DHL's European network. These two fleets achieve 830-1,030FH and 730FC per year, at an average FC time of 1.20-1.40FH. These utilisations are less than half of those accumulated by younger 757-200Fs.

The range of FC times for all 757-200F operations is 1.10-2.75FH, representing a broad range of stage lengths from 350nm, for European operators, up to 1,000nm for FedEx and UPS.

Aircraft characteristics

Most narrowbody freighter types in use or available for future use are analysed here. Aircraft that have been in service for an extended period, and that will probably be considered for replacement by their operators, are the BAE146-300QT, 737-200F and 727-200F. Younger types that may be considered as replacement candidates are the 737-300F, 737-400F, A320F, A321F and 757-200SF/-PCF. The factors that ultimately determine their economic

NARROWBODY FREIGHTER: PAYLOAD SPECIFICATIONS FOR PACKAGE OPERATIONS

Aircraft type	727-200F	A321F	757-200SF ST Aero	757-200PCF Precision
MZFW-lbs	150,000	157,658/162,729	184,000-200,000	184,000-196,000
OEW-lbs	91,700	99,666/99,997	115,500	116,000-116,500
Gross structural payload-lbs	58,300	57,992/62,732	68,500-84,500	67,500-80,000
Maindeck containers	12 x 88/125	13 x AAY	14 x 88/125 plus 1 demi	15 x 88/125
Container tare-lbs	5,088	5,512	6,964	7,140
Container volume-cu ft	5,280	5,720	6,420	6,600
Underfloor capacity-cu ft	1,600		1,790	1,790
Underfloor containers		10 x LD3-45W		
Container tare-lbs		1,810		
Container volume-cu ft		1,270		
Total container tare-lbs	5,088	7,322	6,964	7,140
Total capacity-cu ft	6,880	6,990	8,210	8,390
Net structural payload-lbs	53,212	50,670/55,410	61,536-77,536	60,360-72,860
Volumetric payload @ 7lbs/cu ft	48,160	48,930	57,470	58,730

performance are their volumetric payloads, cash operating costs, and financing costs or lease rates.

The important characteristics affecting an aircraft's volumetric payload capacity are the gross structural payload, the number of containers that can be used on the maindeck, unit tare weight and volume of maindeck containers, and bulk capacity of the underfloor compartment. Volumetric payload is the product of packing density and available volume, and depends on how airlines load their freight on the aircraft maindeck, and how they use the underfloor compartment. "We generally put the large parcels and packages in the containers that are loaded on the maindeck, and put envelopes and smaller packages in bags and load them in bulk in the underfloor compartment. The underfloor compartment can be loaded and unloaded quickly this way," says Rodriguez Anza.

Airlines usually use containers on the maindecks of the aircraft. Except for the A320F and A321F, airlines load freight in bulk in the underfloor compartments of freighters.

The gross structural payload is the maximum zero fuel weight (MZFW) less the operating empty weight (OEW) of the aircraft. MZFW is determined by aircraft design. Most types have several MZFW options, and MZFW can be increased to the highest specification during conversion, and still further in the case of some aircraft types.

OEW depends on various factors. One is the conversion programme used to modify the aircraft, since each one will remove a different amount of weight from the original passenger aircraft, and then add different amounts of weight back to it during modification. OEW is also affected by operator specification, and the weight of crew and manuals carried on the aircraft.

Net structural payload is the gross structural payload less the tare weight of containers or pallets used to carry the freight. Most express-package and postal operations use complete containers, since these can be unloaded and filled more quickly than pallets. Although containers weigh more than pallets, weight is less of an issue since packages and mail have a relatively low packing density and aircraft rarely reach their gross payload capacity.

Several types of container are available for each type. The containers providing the largest amount of volume are used here to illustrate each type's highest possible volumetric payload.

Volumetric payload can also be increased by 25-30% if an airline chooses to use underfloor space.

The aircraft payload characteristics are listed in order of volumetric payload capacity, with freight packed at 7.0lbs per cubic foot *(see tables, page 82 and this page)*.

BAE146-300QT

The BAE146-300QT has a gross structural payload of 29,243lbs, and volumetric payload of 22,764lbs *(see table, page 82)*. It uses seven containers with an 88-inch X 108-inch base, although they are shaped specifically for the BAE146's smaller fuselage. They can be interlined with other aircraft types, but available space will not be utilised.

737-200F

The 737-200F can carry seven 88-inch X 125-inch containers, which is the standard type used on all the Boeing narrowbodies. These are contoured to the fuselage's shape and maximise utilisation of the aircraft's volume. The aircraft also has room for a smaller container at the rear, plus 875 cubic feet of underfloor space. Total volume of 4,307 cubic feet gives it a volumetric payload of 30,149lbs *(see table, page 82)*.

737-300F

In the case of the 737-300F there are up to three passenger-to-freighter conversion modifications available on the market, provided by Aeronautical Engineers Inc (AEI), Bedek Aviation and Pemco. The MZFW of the converted aircraft is similar for all three modifications.

The AEI conversion allows nine standard containers on the maindeck, giving the aircraft a total volume of 5,028 cubic feet. This gives the aircraft a volumetric payload of 35,196lbs.

The Bedek and Pemco conversions allow eight standard containers plus a smaller demi container. The Bedek- and Pemco-converted aircraft both have a total volume of 4,740 cubic feet, and so a volumetric payload of 33,180lbs.

737-400F

The same three companies also offer passenger-to-freighter modifications available for the 737-400F. All three are now available.

The AEI and Pemco conversions both allow carriage of 10 standard containers on the maindeck. In addition to the 1,373 cubic feet of underfloor space, the aircraft has a total capacity of 5,773 cubic feet, thereby providing a volumetric payload of 40,411lbs.

The Bedek conversion allows nine standard containers plus a demi container on the maindeck. Total volume is therefore marginally smaller at 5,683 cubic feet, giving a volumetric payload of 39,781lbs.

A320F

The A320F is the next largest type. Aircraft from line number 1,082, which was built in 1999, have a higher structural payload. The A320F can carry 10 standard containers on its maindeck. It can also carry seven LD3-45W containers in its underfloor compartment, and total containerised volume is 5,289 cubic feet. This gives the aircraft a volumetric payload of 37,023lbs *(see table, page 82)*. The A320F's volumetric payload is therefore about 3,400lbs less

NARROWBODY EXPRESS-PACKAGE TRIP COSTS

Cash operating costs are high for the three older types. The 727-200F's fuel burn of about 2,100USG on a 500nm route compares to about 1,250USG of the similar-sized A321F. The BAE146Q and 737-300F have similar burns of about 1,150USG. The 737-200F burns about 250USG more than the A320F.

Maintenance costs for the older types are generally higher. Airframe-related costs, for line and base checks, are clearly higher due to higher non-routine ratios and ageing aircraft issues. The 727's airframe maintenance costs are at least twice those of the 737 and A320/321. There is less difference in rotable and heavy component costs between the two groups. While older types have less reliable components, their capital costs on the used market are a fraction of the investment required in inventory for the 737-300/-400, A320/321 and 757.

The 727 and 737-200 actually benefit in terms of engine-related costs. The durability and reasonable removal intervals of the JT8D, the simplicity of its shop visits and its low-cost parts all mean its overall reserves per engine flight hour (EFH) are lower than the CFM56-3/-5 and V2500 on the 737 and A320/321. Reserves for the JT8D are about $110 per EFH, equal to $330 per FH for the 727. Engine reserves are $170-185 per EFH for the 737-300/-400, and $180-220 for the A320/321. Reserves for the PW2000 have been used for the 757 on the basis that their lower shop-visit costs will make them the preferred engine type of freight operators.

Total maintenance costs of the older types are $955 for the BAE146-300QT, $1,200 per FH for the 737-200F and $1,500 per FH for the 727-200F. The 737-300/-400 and A320/321 have costs of about $1,100 per FH, while the 757's maintenance totals about $1,400 per FH.

Flightcrew salaries are based on pilot salaries, additional costs of employment and crew productivity. Crews are assumed to operate three nights per week, meaning that each aircraft will require 2.4 crew complements. Captains' salaries range from $60,000 for the BAE146QT up to $80,000 for the 757-200. First officers' salaries are $40,000-55,000. The additional salary for a flight engineer for the 727 is $45,000. Additional employment costs are 35% of salaries. Crew costs are $435-585 per trip with increasing aircraft size, with the 727 having the highest at $765 because of the flight engineer.

Navigation charges are a factor relating to maximum take-off weight (MTOW) and, at a charge of 20 cents per nm, these come to $100-152 per trip. Landing fees charged at $5 per ton of MTOW are equal to $222-580 per trip.

Total cash operating costs are $5,600 for the BAE146-300QT and $6,500 for the 737-200F. This compares to $5,900 for the 737-300F, $6,300 for the 737-400F and $5,700 for the A320F. The younger types clearly have an advantage over the 737-200F, which has the smallest payload. The 727-200F's cash operating costs are $9,700, which compares to $6,500 for the A321F and $8,100 for the 757-200F. Again, the younger types with at least equal payloads have an advantage. The 757-200F's costs per lb of payload are a third lower than the 727's costs per lb.

Aircraft financing evens out the differences. The BAE146QT's lease cost per trip is $1,400, which compares to about $2,100 for the 737-300F. The 737-300F provides more than 50% additional payload.

The 737-200F's lease costs per trip are just $460, which compares to $2,100, $2,500 for the 737-300F and -400F, and $2,800 for the A320F which have volumetric payloads that are 23%, 34% and 23% higher.

The 727-200F's lease costs are $575 per trip, compared to $3,300 for the A321F and $3,600 for the 757-200F.

Overall costs per trip are $7,000 for the BAE146-300QT, $6,900 for the 737-200F and $10,250 for the 727-200F. This compares to $8,000 for the 737-300F, $8,700 for the 737-400F, and $8,500 for the A320F. These three younger types also have the same cost per lb of payload as the 737-200F and the 727-200F. Moreover, the 737-300F/-400F and A320F would have lower costs per lb with fuel prices higher than $2.80 per USG. This means the 737-300F/-400F and A320F are all more economic than the 727-200F for payloads up to 37,000lbs.

The A321F's trip cost of $9,750 gives it a lower cost per lb than the 727-200F, meaning that the A321F is the most economic aircraft for loads between 37,000lbs and 48,900lbs. The 757-200F, with trip costs of $11,750, is the only narrowbody for loads higher than 48,900lbs. The 757-200F also has lower trip costs than the A310-200F and A300B4-200F, meaning that the 757-200F is the better aircraft where these widebodies are being operated at medium loads over the long term.

than the 737-400F's.

The A320F is not yet available, but the first converted aircraft will enter service in 2012.

A321F

The A321F is available as the -100F or -200F, the latter having a higher gross structural payload. The A321F can carry 13 standard maindeck containers plus 10 LD3-45W containers. Total volume is 6,990 cubic feet, and the aircraft has a volumetric payload of 48,930lbs *(see table, page 84)*. The heavier -200F therefore has no advantage with freight packed at 7lbs per cubic foot.

727-200F

The well-established 727-200F still operates in large numbers, although its major operators have phased out some of their fleets. FedEx still operates 77, down from 144 in 1999. A few airlines have added a small number to their fleets.

The 727-200F has a gross structural payload of 58,000lbs, can carry 12 standard containers on its maindeck, and has a net structural payload of 53,000lbs *(see table, page 84)*. Together with its underfloor capacity, the aircraft has 6,880 cubic feet and a volumetric payload of 48,160lbs. This makes it larger than the 737-400F and A320F. The 727-200F is close to the A321F in volumetric capacity and payload. The A321F, however, has the advantage of being able to carry containers in its underfloor compartment.

757-200F

There are two main passenger-to-freighter conversion programmes for the 757-200F: the Boeing modification, which is performed by ST Aerospace; and the Precision Conversions modification. Both have a range of MZFW and gross payload options. The Boeing modification allows 14 standard containers and one demi on the maindeck. There are another 1,790 cubic feet of underfloor capacity, taking total volume to 8,210 cubic feet. Volumetric payload for this aircraft is 57,470lbs *(see table, page 84)*.

The Precision Conversions modification allows 15 full containers on the maindeck, so total capacity is 8,390 cubic feet. Volumetric payload is 58,730lbs, 1,260lbs more than the ST Aerospace conversion *(see table, page 84)*.

These eight aircraft types therefore provide a wide range of volumetric payload capacities from 22,760lbs to 58,730lbs. The five younger types have capacities from 32,000lbs to 58,730lbs, with the 737-300F being the smallest freighter in the category of younger aircraft.

Economics

In selecting the right aircraft or aircraft types, several issues have to be considered. The general wisdom is that the older aircraft types with low capital costs and lease rates are the most economic for low utilisation freight operations. Younger aircraft have high capital costs, but these are offset to varying degrees by their lower direct operating costs. Younger types will become more attractive with higher long-term fuel costs, and with the increasing maintenance and technical support costs of older types. The two other important variables are aircraft utilisation and financing cost.

Airlines first need to be aware of the amount of capacity they require on each route. Freight volumes on each route, the variation in freight volumes, and packing densities will determine the appropriate volumetric capacity required. Freight carriers will want to avoid spillage of freight, but will also want to achieve the highest possible load factors to generate the highest possible revenues to cover operating costs.

The economics of each aircraft is basically the gross margin left by the difference between freight revenue and aircraft-related costs. An A321F is therefore likely to generate a smaller gross margin than a 737-300F that has a 44% smaller volumetric payload when a load smaller than 32,000lbs is being carried. The issue is whether the A321F is the best choice with larger loads and of payloads up to its capacity of 48,930lbs. The 757-200F will clearly be the most economic aircraft with loads larger than this.

Determining relative economic differences starts with modelling an overnight, express-freight operation. A 500nm route has been used, and an operating pattern of one return flight per night, equal to 730FC per year has been used. The flight time for a 500nm route is about 85 minutes for most types, although the BAE146QT is marginally slower. Annual utilisations are in the order of 1,200FH.

Direct operating costs included are the three main categories of fuel, aircraft direct maintenance, and flightcrew. Fuel costs are a product of unit fuel price and fuel burn on the 500nm route. The fuel price used is $2.80 per US gallon (USG), the spot price when crude oil is at $100 per barrel. This is higher than current oil prices, but forecasts are for the price to increase to at least this level.

Smaller costs of navigation and landing fees are also added.

Financing costs are less exact, since airlines can use a range of financing techniques. The BAE146, 737-200F and 727-200F will have been acquired over an extended period, at a wide range of aircraft ages, and with a variety of financing techniques. Some aircraft will be owned and completely or nearly depreciated, while others will have been leased at a range of lease rentals. Using a representative lease rental or financing cost is vague. Market lease rentals from 2003-2005 have been used to illustrate what lease rates operators may have locked themselves into if they had signed leases at this time. These are in the order of $50,000 per month for the BAE146-300QT, $28,000 for the 737-200F, and $35,000 for the 727-200F. Lease rates would clearly be less than this in the current market, but no airlines are likely to be leasing any more of these types to their fleets.

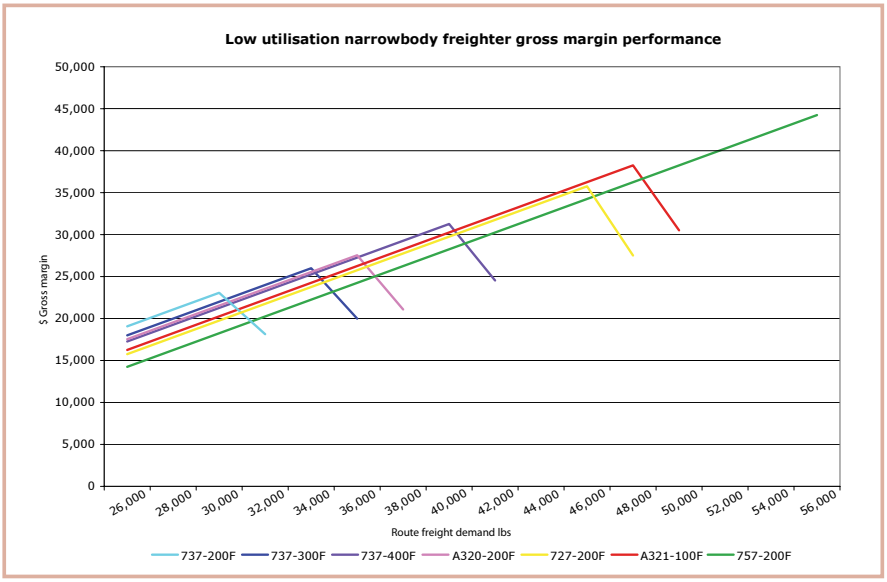
Lease rates for the younger types are the expected market rates in conditions where aircraft are being actively converted and leased. The monthly rates are $130,000 for the 737-300F, $150,000 for the 737-400F, $170,000 for the A320F, $200,000 for the A321F, and $220,000 for the 757-200F.

These lease rates are high for some individual aircraft. Lease rentals for 737-300Fs and -400Fs could reduce following retirement of large numbers of passenger aircraft. This would lead to a drop in values, reducing the total build cost of freighters that would allow lower lease rates.

The oldest 757-200s built, for example, have market levels in the $6-8 million range. Although these will have the lowest gross payloads, they provide sufficient capacity of express-package operation. When adding the conversion and maintenance costs of about $4.5 and $1.5 million respectively, the total investment of $12-14 million can be covered in a lease rental of $180,000-210,000.

As discussed, the important issue is the gross margin that each aircraft can generate for a range of different payloads, and not just its trip cost and cost per lb of full payload. Demand and payloads carried vary. Gross margin rises with higher loads and revenues as trip costs remain almost constant, and each aircraft will deliver its highest gross margin when it reaches a full payload. The better aircraft are those which deliver the best gross margin over the widest range of demand levels. The 737-300F/-400F and A320F/321F both have the advantage of commonality between two types, so they can carry a wide range of payloads with similar aircraft and so avoid the additional overheads associated with using two aircraft types.

The gross margin with a range of payloads is calculated using an arbitrary yield of $1 per lb. This provides the gross margin profile for each aircraft for a single trip *(see chart, this page)*.



Analysis

Several conclusions may be drawn from the results. First it should be appreciated that there are many variables which can alter the relative differences between aircraft types. The first is that fuel prices and aircraft financing charges can vary widely from the ones used here. Fuel prices are likely to remain high and fluctuate at least until significant quantities of alternative fuels are available. This is unlikely to happen for at least another 10 years. Many freight carriers, such as Kelowna, own their aircraft and have fully depreciated them, so they have have zero financing charges. Lapointe at Kelowna points out that this makes it hard to justify replacing the 727-200, even with high fuel prices.

Other basic cost variables are pilot salaries and the total cost of employment.

Other variables are aircraft volumetric capacity, which varies according to packing density. A lower

A main issue in freighter performance and selection is usable freight capacity. This in turn is dependent on freighter conversion programme and the number and type of containers that can be used by the aircraft.

packing density means that aircraft will become full for a smaller quantity of packages and revenue. Airlines will have to change up to a larger aircraft type and increase their costs. If freight is packed at lower densities than the 7lbs per cubic foot used here, the relative differences of gross margin between types would alter.

Several other cost categories have been left out of the analysis. These include ground handling, additional crew members, and insurance. Freight yields can also vary widely, and the gross margins that aircraft generate also have to contribute to ground transportation and other costs that couriers incur. The BAE146-300QT is not included in the analysis. Its trip costs are about $7,000, about $100 more than the 737-200F. The BAE146-300QT's volumetric payload is about 7,500lbs less than the 737-200F's. Moreover, the BAE146's volumetric payload is about 35% lower than the 737-300F's, while the 737-300F has just a 14% higher trip cost.

Several aircraft types and fleet scenarios have to be considered. The 737-200F clearly has the best performance of all types up to its payload limit, indicating that it is a good choice for small volume markets. Few 737-200Fs are available, so its capability is almost academic. Turboprops are the only choice for airlines with small volumes.

The 737-300 is the only choice for airlines with traffic loads greater than the largest turboprops, and is the most economic aircraft up to about 35,000lbs when the -200F is discounted *(see chart, page 87)*. The 737-300F has a gross margin performance close to the A320F's, which is only about $450 less due to its higher trip costs.

The 737-400F has the third best performance, at low demand levels, having a gross margin about $300 less than the A320F and $1,000 less than the 737-300F, due to equal differences in trip costs. The 737-400F is also the best option for volumes between 34,000lbs and 40,000lbs *(see chart, page 87)*, since the A320F's capacity is only 2,000lbs more than the 737-300F's.

This raises the issue of how mixed fleets of 737-300F/-400Fs and A320F/321Fs compare. The conclusion is clear. The 737-300F/-400F provide the best, and only, economic solution for lower demand levels up to about 40,000lbs *(see chart, page 87)*. Where an airline has higher average traffic volumes of 42,000-48,000lbs on some of its busier routes, the A320F/321F are the better solution *(see chart, page 87)*. This, of course, is only the case when aircraft are operated at the costs described, and when both converted aircraft are available in sufficient numbers. This will not be the case for at least three to four years.

The next issue is the 727-200F's performance. The closest direct competitor is the A321F, because of its similar volumetric payload. Using the cost parameters described, the 727-200F has poorer economic performance than the four younger narrowbody types in the order of $500-2,000 per trip *(see chart, page 87)*. Even if the financing charge for the 727-200F is changed to zero, its trip costs are still higher than those of the 737 models and A320, and it becomes closer in operating cost to the A321. The 727-200 currently operates in large numbers because there is not yet a direct replacement in capacity terms. Airlines that consistently experience low traffic volumes can justify the 737-300F/-400F, and the A320F/321F will be the better option when they are available in large numbers.

The 757-200F is clearly the only option for higher freight volumes and demand levels. While it has higher trip costs than 727-200Fs at low financing charges, the 727 faces several problems that give it limited remaining time for most of its operators. The first of these is that fuel prices are likely to rise to $3.50 per USG, which is experienced at a crude oil price of $130 per barrel.

The 727 also has a batch of heavy ageing aircraft inspections due when it reaches a total of 55,000FC. This will clearly raise maintenance costs, although there are large numbers of aircraft in the fleet that have not yet accumulated numbers of FCs close to this threshold.

While 727s increase with age, the availability of used passenger 737s, A320s/321s and 757s will increase, thereby lowering their market values, and making it easier to justify the total cost of acquiring and converting them to freighter.

As described, older 757-200s can be acquired and converted and economically leased for express-package operations at about $190,000 per month. At this rate the aircraft provides the most economic solution for freight volumes from about 40,000lbs.

The 757-200 is also cheaper to operate than the smallest widebody freighters. The A310-200F and A300B4-200F have trip costs $3,500-4,500 higher than the 757-200F.

The A310 has a volumetric payload of 70,000lbs, just 11,300lbs more than the 757. The A300B4-200F has a volumetric payload of 82,990lbs, just 24,260lbs more than the 757-200F. The two widebodies therefore need to experience load factors consistently above 85% and 75-80% respectively to justify their continued operation. If lower freight volumes are experienced then the 757-200F provides the more economic long-term solution. AC