The MD-11F and 747-400F have overtaken the 747-200SF as the dominant 100-ton freighters, which has been aided by a reduction in financing costs, increased aircraft utilisations and high-traffic growth. At what level of operation do new aircraft become more economical than converted?

100-ton freighters: converted or new?

Determining which 100-ton freighter is the best choice for an airline first requires analysis of its operation. Carriers that operate the MD-11, 747-200 and 747-400 fall into one of four different categories: express small-package airlines; wet-lease (ACMI) operators; airlines operating scheduled services carrying general freight; and operators flying on an ad-hoc charter basis.

Each category of airline experiences different load factors and yields, operates at different rates of utilisation and charges revenues by different methods.

ACMI carriers charge a fixed dollar rate per block hour (BH) at a pre-agreed aircraft utilisation, irrespective of load factor. Express small-package airlines have scheduled operations and load factor is often low. In some cases small package carriers, or integrators, will use the MD-11 or 747 with containers smaller than the maximum possible size so that they can interline with other aircraft types. In this case yields are generally high, but payloads low compared to structural capacity.

100-ton market

The market for 100-ton aircraft totals about 300 units and is expected to treble over the next 20 years. The fleet will experience a net increase of about 700 aircraft, because 120 aircraft are anticipated to retire over this period.

Almost all MD-11s will be converted, meaning about another 100 units will be modified. A total of 410 conversions are expected, including about 300 747s (-200s, -300s and -400s). The remainder of the fleet expansion will come from about 300 new 747s and A380s.

The number of 747-200 conversions has been continuously revised down in recent years. This has followed the increasing popularity of new factory-built 747-400s and MD-11 conversions. This is explained by the high traffic-growth rates in long-distance markets. These are between Europe and the Asia Pacific and the trans-Pacific. These networks and high traffic volumes have allowed airlines to generate high utilisations from their aircraft, thereby diluting finance charges and making the 747-400F more economical than the 747-200SF.

Converted 747s have remained the more economical aircraft where utilisations have stayed low.

The 747-400 also has a payload of about 34,000lbs higher than a higher specification -200SF. This allows the -400F to generate about 17% more revenue at a 100% load factor. A higher rate of utilisation is key to the 747-400F being a more economical choice.

The MD-11 falls between a converted 747-200SF and 747-400F in terms of age and capital cost. This is because the majority of MD-11Fs have been converted at an early age. Build cost for a MD-11F is $55-70 million *(see MD-11 for freight conversion: a good buy if you can get one, Aircraft Commerce, November/December 2000, page 43)*. This compares to $30-43 million for a high gross weight 747-200SF *(see The merits and pitfalls of buying used 747-200s, Aircraft Commerce, November/December 1999, page 13)*, and a possible purchase price of $125-140 million for a 747-400F.

Although the MD-11F's build cost is high for a passenger-converted aircraft, this can be amortised over an extended period with debt financing. Lessors will be able to arrange one or two debt terms with balloons payable at the end, which are paid from the re-sale value of the aircraft. This mechanism will generate a respectable increase in equity for the aircraft owner, and will allow lease rates to be charged in the region of $500,000 per month, while generating a high return for the equity investor.

This lease rate compares with market rates of $450,000 for a high gross weight 747-200SF. Lease rates for the type were higher, but in recent years have come under pressure from the presence of larger numbers of 747-400Fs and MD-11Fs.

Customers

The majority of MD-11 operators are freight divisions of major passenger airlines, which converted aircraft, because used market prospects were poor and modification of MD-11s was a better prospect than acquiring older converted 747s. Gemini is the one wet-lease operator, while FedEX and UPS are the two integrators. There are no independent specialist general freight carriers.

The 747-100SF/-200SF fleet is operated by a wider mixture of specialist freight, integrator, wet-lease and major passenger-airline freight-division operations.

The 747-400F fleet, which has grown rapidly in the past three or four years, is dominated by freight divisions of major passenger carriers, but also by Atlas, which operates wet leases for other major passenger carriers. Cargolux is the only specialist general freight airline to use the aircraft. This dominance of the -400F market by major passenger carriers perhaps reflects the importance of being able to guarantee high utilisation rates and loads.

Increased popularity of new 747-400Fs over converted aircraft has been aided by purchase discounts and low interest rates. These are two factors which have helped lease-rate factors drop to as low as 80 basis points per month. Low lease rates combined with high utilisations have made the 747-400 economically acceptable over a wide range of operating conditions.

Economic dynamics

Selection of the most economical 100-ton freighter is complicated by a variety of factors. Ultimately, the operator will look for the type which generates the highest gross profit.

Revenues and operating costs will have to be taken into consideration. Revenues are paid in a variety of ways. Wet-lease operators bill a pre-agreed amount per flight hour, while other carriers charge per lb, cubic foot or shipment.

Factors affecting costs and revenues are first complicated by the fact that aircraft capacity is not fixed. The most common MD-11 version has a structural payload of 189,000lbs, the 747-200SF 214,000lbs and 747-400F 248,000lbs. The corresponding range for these maximum payloads is 3,800nm for the MD-11F and JT9D-7Q-powered 747-200SF, and 4,400nm for the 747-400F. The rate at which available payload reduces with increased route length after these distances is one of the major influences on aircraft selection. The MD-11F and 747-400F can both fly up to about 8,800nm before their payloads are zero. The corresponding range for a -7Q-powered 747-200SF is about only 7,200nm.

The 747-200SF's payload capability therefore deteriorates the fastest with increased range after 3,800nm. Although its maximum payload exceeds the MD-11F's, the MD-11F is able to carry more than a -7Q-powered 747-200SF after about 4,800nm. There are several variants of the 747-200SF, with different engine types and maximum take-off weights (MTOWs).

The 747-400F's payload capacity always exceeds the -200SF's, but the MD-11F's payload does not deteriorate as fast as the 747-400F's. This means that on the very longest routes the MD-11F and 747-400F have similar revenue-generating capacities.

The first concern is therefore the freight load of each route. In many cases there are large bi-directional discrepancies in cargo types carried, revenues per unit weight and loads. Demand varies in the same way that passenger loads do, and so freight carriers are sensitive to 'spillage'. Sensitivity increases with larger bi-directional discrepancies.

The payload carried also depends on packing density. Low packing densities will allow aircraft to 'bulk out' before full structural payload is reached, allowing a longer range and route length than higher-density material. Therefore, a 747-200SF's volume of 26,000 cubic feet may be filled, but a payload of only 156,000lbs will be carried when packed at 6lbs per cubic foot allowing a range of about 4,800nm. Higher-density material of 8lbs per cubic foot would be 208,000lbs, and the aircraft would have a reduced range of 4,200nm. Thus, the lower the packing density the less critical or problematic is the aircraft's deterioration in range performance. With lower packing densities, older types therefore have a smaller payload differential with younger types compared to higher-density cargoes.

Conversely, the higher the packing density the shorter the range of the aircraft. Modern aircraft therefore have an advantage with high-density cargoes, while older aircraft have an advantage with low-density freight.

Traffic demand

Like passenger operations, freight carriers have to plan for average load factors to avoid 'spillage', or lack of capacity to carry demand on extreme occasions when demand is high. Planned average load factor may be close to 70%. When this average starts to be exceeded, capacity has to be increased by adding a frequency or using a larger type.

Low levels of demand favour smaller aircraft types. Although the 747-400F has a payload of 34,000lbs, which is 16% higher than that of the -200SF, the -400F is only required to carry more where average demand on a route exceeds the -200SF's 70% load factor point of 150,000lbs. If the -200SF and -400F have equal trip costs, the -400F will only be the more economical by generating a higher gross profit, when average demand is more than 150,000lbs and its higher capacity is therefore required.

Again, a younger type's structural payload advantage over an older aircraft will be diminished for cargoes packed at low densities because the weight differential between the two will be reduced. The 747-400F, for example, has only about 1,000 more cubic feet of containerised volume than a -200SF.

If demand is at a level where all three types can operate without the risk of spill, the revenue generated by each will be equal. The gross profit generated by each will therefore depend on its trip costs.

Younger or larger aircraft will only have an advantage when demand is high, while smaller or older types would have to operate at a higher frequency and incur higher trip costs.

Trip costs are also affected by aircraft utilisation and mission length. Aircraft finance or lease costs reduce as a percentage of total operating costs as utilisation and mission length rise. These bring the MD-11F's and 747-400F's trip costs closer to the 747-200SF's, which has a lower lease rate. Growth in long-distance, general-freight markets between either Europe or North America and the Asia Pacific explains the 747-400F's increased popularity with Singapore Airlines, China Airlines, Asian Airlines, Korean Air, Cathay Pacific and EVA Air. These carriers account for about 65% of the 747-400F's orders, and are able to generate high utilisations. Cargolux,

which has replaced all its 747-200s with -400Fs, achieves utilisations of 5,500FH per year.

747-400F wins favour

The increase in 747-400F orders in recent years has caused the forecast for 747-200 conversions to be revised down. The -400F's popularity is due to high growth in long distance markets. This results in loads higher than required by the -200SF, but also increases aircraft utilisation. It has always been the general rule that freight operations generate lower utilisations than passenger ones. Low aircraft capital cost is therefore the main driver in freight aircraft selection. Until high traffic growth, it was hard for the -400F to beat the -200SF's economics. In the past, 747 freighter utilisations were in the region of 3,500 BH per year. It is not uncommon for -400F operators to achieve 5,000BH annually.

The -400F has also been helped by the general decline in aircraft-financing costs. The fall in interest rates has meant that monthly lease-rate factors for new aircraft have fallen from 1.1% to 0.8-0.9% of capital cost. A 747-400F acquired for a discounted purchase price of $125 million will therefore have a $250,000 per month lower lease rental. This drop in lease-rate factors has narrowed the gap in trip costs between the 747-200SF and -400F. Some 747-400F lease rates are reported to be as low as $875,000 per month.

Since the 747-400F's recent rise, the -400F and -200SF have been polarised into two markets or niches which have become more distinct. This has resulted in the -200SF (and -100SF) being relegated to shorter distance and lower-utilisation operations, while the -400F has been used by carriers that require the aircraft's higher capacity and, more importantly, generate higher utilisations.

There is therefore a cross-over point, or set of operating circumstances and freight volume, at which the MD-11F, 747-200SF and 747-400F are each the most economical to operate in terms of generating the highest gross profit.

MD-11 & 747 economics

To illustrate the set of circumstances at which the MD-11F, a -7Q-powered 747-200SF and 747-400F generate the highest gross profit, three analyses have been made.

These are all based on the aircraft being able to use their full structural payloads. Packing densities of cargoes are therefore assumed to be high enough to allow full utilisation of structural payload, unless restricted by range. Payloads are also assumed not to be limited by total aircraft containerised volumes being less than the maximum possible.

In the case of small-package operations, both densities and total containerised volumes are low, limiting the aircraft's weight payload to less than the structural payload. The difference in available payloads between each aircraft would then be reduced.

The three scenarios studied are sector lengths of 2,500nm, 3,500nm and 5,000nm. Corresponding annual aircraft utilisations for the three aircraft types in each case are 3,000BH, 4,500BH and 5,000BH. The older 747-200SF may not actually be able to achieve such high utilisations as the MD-11F and 747-400F on the longer routes.

Payloads on the 2,500nm and 3,500nm sectors are maximum structural payloads. Payloads on the 5,000nm sector are reduced to 154,000lbs for the MD-11F, 150,000lbs for the 747-200SF and 224,000lbs for the 747-400F.

As route length and utilisations increase, younger types with lower cash costs and better payload-range performance should have better gross profit-generating ability than older types.

The operating costs assumptions used are as follows:

- Fuel price of 80 cents per US Gallon.

- Maintenance costs:
MD-11: $1,350 per BH @ 2,500nm, $1,260 per BH @ 5,000nm.
747-200SF: $2,300 per BH 2,500nm, $2,050 @ 5,000nm.
747-400F: $1,800 per BH @ 2,500nm, $1,600 @ 5,000nm.

- Annual flightcrew costs:
MD-11: $282,000
747-200SF: $419,000
747-400F: $312,000
Annual crew productivity of 550 BH per year.

- Aircraft monthly lease rates:
MD-11: $500,000.
747-200SF: $450,000.
747-400F: $900,000.

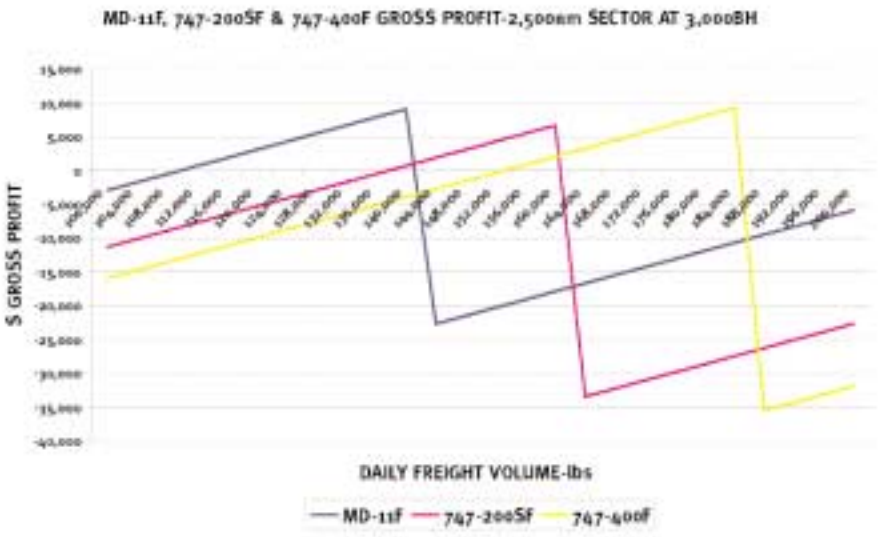
These analyses have been made to reflect different freight loads and the four costs of fuel, maintenance, flight crew and finance charges. A yield per lb generates a revenue level and gross profit left to cover navigation and landing fees and freight-handling charges. The last of these can be high, and are fixed irrespective of sector length.

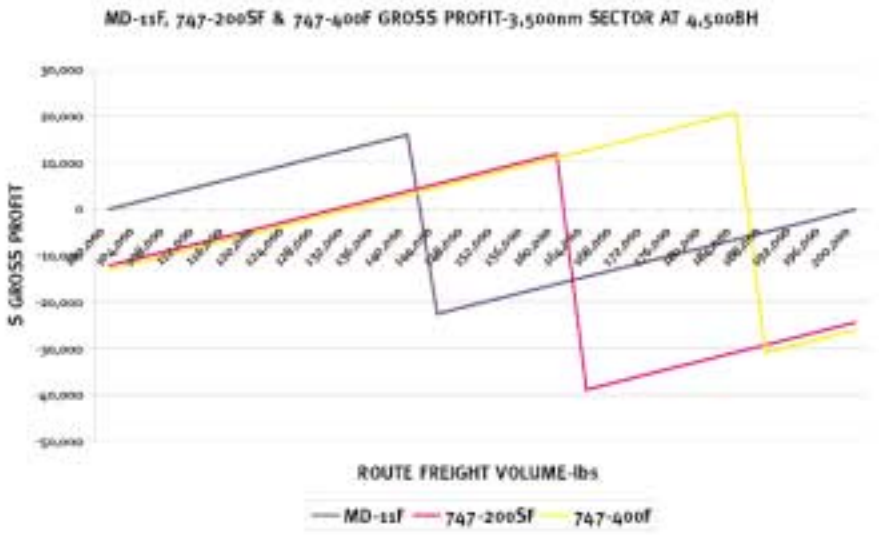
Unit revenues in these analyses are arbitrary, but still reflect what the relative difference in gross profit between the three types will be *(see charts, this page)*. They also illustrate the levels of freight volume over which each aircraft type generates the highest gross profit.

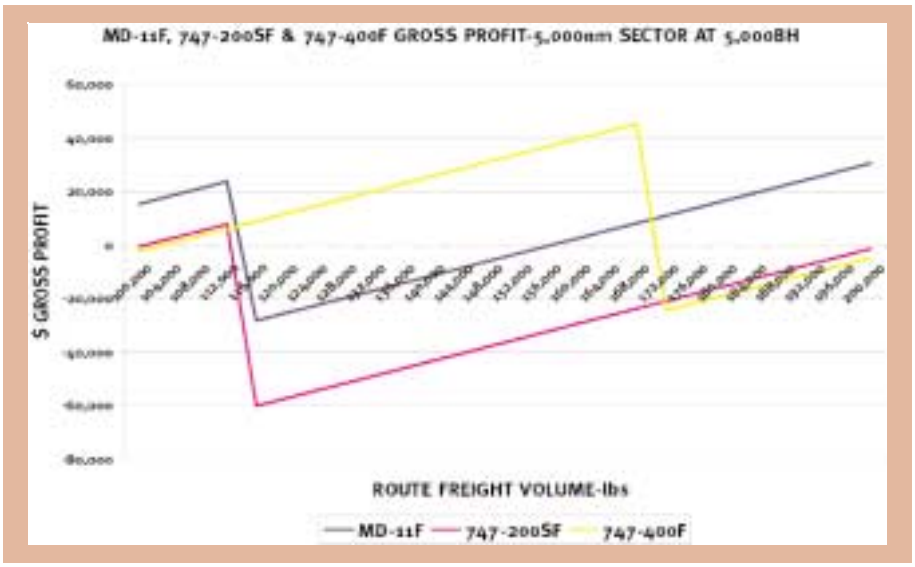
The first analysis uses a unit revenue rate of 30 cents per lb. The unit rates for the 3,500nm sector are 40 cents per lb, and 70 cents per lb for the 5,000nm average route length.

Actual general freight yields are in the region of 45 cents per revenue tonne kilometre. This translates into rates of $0.95, $1.33 and $1.89 per lb for these three sector lengths. Although these are considerably higher than the analyses, the analyses omit many of the non-aircraft-related costs incurred by airlines.

Each of these analyses assumes that the airline will choose to increase capacity by adding a frequency when average demand has reached a load factor of 75%. At this point costs are increased by another aircraft trip, while a larger type can continue to operate at one less frequency. At the same daily freight volume on a route each aircraft type will generate the same revenue. The gross profit each type generates will therefore depend on its trip cost and daily frequency.







2,500nm & 3,000BH

On short sectors and low utilisation, the 747-200SF is able to take advantage of its low lease charges and have trip costs of $41,500; $4,500 less than the 747-400F. Until the -200SF reaches a 75% load factor, it is more economic than the -400F *(see first chart, page 51)*.

The MD-11F's trip cost is $8,300 lower than that of the 747-200SF. Consequently the MD-11F is the best aircraft for volumes up to 142,000lbs (a 75% load factor). The freight volume level over which the 747-200SF is the most economical is therefore only 20,000lbs wide. This point illustrates why the conversion of so many MD-11s

The MD-11 can carry 88% of the payload of a converted 747-200SF for 75-79% of the trip cost. Lower-density cargoes bring the capacities of the two aircraft closer together, favouring the MD-11 even more. If airlines impose load-factor constraints of 70-75% on themselves to avoid 'spill', the 747-200F's additional 12% freight capacity is reduced to an advantage of just 9%. These factors explain why MD-11 conversions have been favoured over the 747-200SF.

to freighters by their operators has been one of the first factors to reduce the market for 747-200 conversions.

The band of freight volumes at which the 747-400F is the most economical type is between 162,000lbs and 186,000lbs.

3,500nm & 4,500BH

For a slightly longer sector length and higher rate of utilisation, the relative difference between the three types is unchanged *(see second chart, page 51)*. First the daily freight volumes at which each type has the highest gross profit are the same as in the first analysis, because available payloads and 75% load factors are unchanged.

The higher rates of utilisation, however, reduce the gap in trip costs between the 747-200SF and -400F. They also give the MD-11 a better cost difference to the 747-200SF compared to lower utilisations.

The gap in trip costs between the two 747 variants is reduced to about $750. This then means the 747-400 can generate a gross profit almost equal to the 747-200SF over daily freight volume at which the 747-200SF is slightly more economical. This therefore shows that this sector length and rate of utilisation are the point at which the -400F starts to become as economical as the -200SF for the same payload. The daily freight volume at which the 747-400F generates an equal or better gross profit is 142,000-186,000lbs; 24,000lbs wider than in the first analysis. This indicates why the 747-400F has started to overshadow the 747-200SF.

The 4,500BH rate of utilisation in this analysis makes the MD-11 more efficient, increasing the difference in gross profit it can generate over the 747-200SF by about $12,000. Again, this underlines why the MD-11F has reduced the market for 747 conversions.

5,000nm & 5,000BH

The restricted payloads of the MD-11F and 747-200SF provide the 747-400F with a large advantage. As the MD-11 and 747-200 both have payloads that are one-third smaller than the 747-400, it has a much wider daily freight volume over which it generates the highest gross profit. This is 114,000-170,000lbs *(see third chart, page 51)*.

This high rate of utilisation also means the difference in trip costs between the 747-200SF and -400F is only about $1,500 in the -200SF's favour. Its lower payload, however, favours the -400F.

One possible means whereby the -200SF can overcome the -400F's 74,000lbs payload advantage is that it allows, in some cases, operation of two 2,500nm sectors. The -400F's 5,000nm trip cost is, however, 12% lower than the -200SF's doubled 2,500nm trip cost.

As the MD-11 and 747-200 have the same capacity on this route length, the MD-11 has the best performance because of its lower trip cost at all freight volumes.

The 747-200SF is therefore not able to generate higher gross profits than the MD-11F or 747-400F at any level of demand.

This sector length and rate of utilisation therefore reveal the point at which the MD-11F and 747-400F exceed the 747-200SF. It further demonstrates how the 747-400F is by far more economical an aircraft than the 747-200SF at this level of operation.

Summary

The MD-11F is the preferred aircraft over the 747-200SF at lower volumes for all levels of utilisation and average sector length. Where the MD-11F's and 747-200SF's payload is limited by packing density, container volume or range, the MD-11F's payload will be similar to the 747-200SF's, making the former uneconomical in most circumstances.

The point at which the 747-400F's economics start to improve on the -200SF's is on medium- and long-haul operations, and when aircraft utilisation exceeds about 4,500FH per year. The 747-200SF still has an advantage on short-range missions when low utilisations are achieved.

The relative difference between the 747-200SF and -400F is dependent on the difference in lease rates. In these analyses it is only $450,000. In many cases it will be higher, unless Boeing is prepared to offer deep purchase discounts. The analyses reveal why 747-200SF lease rates have had to fall by more than $200,000 per month in about only five years. If an airline is unable to acquire the 747-400F for as low as the $900,000 rate used here, the 747-200SF will generate a higher gross profit than the -400F as shown here. The 747-200SF will thus be able to maintain a sizeable market.

In the case of small-package operations, the packing densities and containers used to make interlining with smaller aircraft types possible will combine to make the maximum payloads of the three types closer than their structural payloads. This means they will have to add additional frequencies at similar levels of daily demand. The MD-11F will therefore always generate the highest gross profit because its trip costs are lower than those of both 747 variants.

The risk associated with the 747-400F is that freight traffic could decline, and operating conditions revert back to those which favour the 747-200SF. Many airlines have suffered this problem in the past six months, and many aircraft of several types have been parked. Sustained traffic recovery is required to keep younger aircraft operational.