It is no longer viable to convert 747-200s to freighters. Studies are being made to develop conversion programmes for the 747-400. The values of 747-400s are now coming down to a level that would result in a build cost that would generate a lease rate acceptable to potential operators.

The case for a 747-400 freighter conversion

With the prospect of the first converted 747-400 freighter (747-400SF) becoming available in 2003-2004, what is its market, and how do its economics compare with alternative aircraft?

It is estimated that a 747-400SF would be able to command a monthly lease rate of $550,000-650,000, suggesting the total build cost could exceed much more than $50 million. At least one 747-400 freighter modification programme is under development, and Boeing may yet also develop a supplemental type certificate (STC). An independent STC and freight handling system would have a price in the region of $20 million, implying that market values would have to fall to about $30 million. "These have probably been reached, although no operators have yet been forced to sell their aircraft," says John Flynn, president at Triton Aviation.

Case for 747-400 conversion

The market for 747-100/-200/-300 conversions has almost dried up in recent years. This is due to the aircraft being economically squeezed on either side of their payload capacity by the MD-11F and 747-400F. A 747-400SF could fill the gap left by the 747-200SF.

With typical freight densities of 7.5lbs per cubic foot, the MD-11F can carry up to 151,000lbs, while the 747-200SF can accommodate 200,000lbs. The MD-11 can thus compete, in payload terms, with the 747-200SF up to payloads of 151,000lbs.

The MD-11F has lower fuel, maintenance, landing, navigation, spare engine and flightcrew cash operating costs than the 747-200SF. The MD-11F has a market lease rate in the region of $450,000 per month, while the 747-200SF was being leased out at similar rates until late 2000. The MD-11F is therefore more economic when carrying the same payload and revenue.

The 747-400F has pushed the 747-200SF aside on many routes and networks. High traffic growth rates until late 2000 led to operators achieving rates of aircraft utilisation as high as 375FH per month or 4,500FH per year, thereby justifying the -400F's high capital cost. The -400 also has cash operating costs up to $1,500 per flight hour (FH) lower than than the -200SF, making the -400F more economic.

The -400F has been aided by attractive purchasing and financing terms, with airlines able to acquire aircraft at rates of about $900,000 per month. This is about $450,000 per month more than the cost of a -200SF could be leased for until late 2000. The -400F's higher financing cost is equal to a difference of about $1,200 per FH, so the -400F has an overall cost advantage of about $300 per FH over the -200SF.

Lease rates for the -200SF have had to soften to less than $300,000 to overcome the -400F's advantages. These low rates are only viable for aircraft that have already been converted, since they are too low for lessors to recoup the cost of acquiring used aircraft and converting them to freighters. Even 747-200s acquired at low market values in the region of $8 million will have a total build cost of $22-24 million. This would require a lease rate of about $360,000 per month sustained for a long period, plus the prospect of a reasonable residual value for an investor to recoup the investment. Since this is unlikely, no more 747-200s are likely to be converted.

Many carriers have ordered large numbers of -400Fs in the past six years. These include Singapore Airlines (SIA), Cathay Pacific, China Airlines, Air France, Cargolux, Atlas Air and Polar Air. The -400F is also 15-20 years younger than the -200SF.

The fall in freight traffic in 2000 and 2001 made it hard for these airlines to maintain the levels of utilisation necessary to keep the -400F competitive. Atlas Air, for example, deferred delivery of two -400Fs.

A converted 747-400SF will be available at finance rates equivalent to 50-60% of a new -400F, and will provide operators with the best of both worlds: the cash operating costs of the more efficient 747-400 and the low financing costs of a converted aircraft.

Not all freight operators are convinced the -400SF would have much of a cash operating cost advantage over the -200SF. "The -400SF would only have a fuel and maintenance cost advantage over the -200SF," comments says Fred de Leeuw, senior vice president of strategic planning at Atlas Air. "Under US rules a two-man flightcrew is only allowed up to eight hours. The 747-400SF will need a supernumerary crew member on routes longer than about 3,500nm, which is the sectors it would be most appropriate for."

The MD-11 provides the most economic solution for payloads up to 175,000lbs. The aircraft has the efficiencies of three engines and a two-man flightcrew to overcome the 747-200SF. This is a major factor in the reduction in 747-200 conversions.

747-400SF market

The first market for a 747-400SF is providing higher capacity to accommodate growth for MD-11 operators. One possible example is the case of UPS, which has selected the MD-11 for its international network, in particular across the Pacific. "When we ran the competition for the MD-11 we included a theoretical 747-400SF, as well as a theoretical converted A340," says Bill Simpson, long-range planning manager at UPS. "The 747-400F and -400SF are good for long-range routes, but their capacity exceeded our needs on several sectors. The MD-11 is the better overall fit in the system. When the -400SF's capacity appeals across more routes in the system it may also come available at the right time, but the current downturn makes it hard to determine when we might need a larger aircraft. The evolution of our system has always led to larger aircraft in the long-term, and so we may need a larger type in 3-10 years."

Other markets for the 747-400SF include replacing or supplementing 747-100/-200s, while a third is to offer airlines a lower capital cost alternative to the 747-400F.

Conversion conditions

A 747-400SF will only become available if certain market conditions are met. The prime condition is market values reaching $30 million or less.

"The 747-400 is probably still too expensive to justify conversion, considering its current market value and conversion cost," says de Leeuw. "The -200SF's lease rate is still $300,000. The -400SF's lease rate would have to go down to $450,000-550,000 per month. Also, I do not think the conversion could be done for as low as $20 million, and it is more likely to cost about $25 million. If the -400SF came available at the right lease rate over time it would be a viable -200SF replacement. The most important factor is the purchase cost."

Market values will only be low enough if there is an excess of passenger aircraft. Theoretical market values have dropped, although no real values have been established due to a lack of transactions. There is a glut of 747-400s, however, and United Airlines has parked seven which are excess to requirements. SIA is also thought to have about six aircraft too many, and British Airways is thought to have several aircraft available. Many other 747-400 operators also have excess capacity, and are forced to operate aircraft at low utilisations because a secondary market has not been established for the 747-400. Like all other 747 variants, the -400 is hard to fill and requires the traffic volumes that only major carriers can deliver to make it viable as a passenger aircraft. The prime secondary market for the 747-400 will therefore be conversion to freighter. The glut of 747-400s is partially explained by the lack of a passenger-to-freighter conversion programme.

Other conditions to trigger a conversion programme are a requirement for the aircraft as a freighter and a lessor or specialist freight converter prepared to convert and market aircraft.

A viable freight market will trigger a conversion programme, increasing the requirement for the aircraft as a freighter and encouraging lessors or specialist freight converters to convert and market aircraft.

Traffic grew strongly for most of 2000, but slumped about 9% during 2001 and declined further in the first half of 2002. Growth resumed in some global regions from April and May 2002 at single-digit rates. Traffic volumes should reach 1999 levels by the end of 2002, and then continue growing at about 6% per year. Despite this recovery, two years of traffic growth have still been lost, resulting in overcapacity and the cancellation of orders and aircraft conversion programmes.

A 747-400SF is not dependent on the recovery of traffic growth, since it can provide an economic replacement for the 747-200SF, but there is a requirement for the 747-400SF for the first modifications to proceed. No specialist lessors or converters of aircraft are yet ready to acquire aircraft, but the prime reason for this is the lack of a conversion programme. "We would go into the 747-400 conversion market in about two years if the total build cost of a ready-to-operate aircraft was no more than $50 million and there was a market for the aircraft," says Flynn. "Also, lease rates need to be in the region of $550,000-650,000 per month to justify the investment. This rate is in contrast to the $400,000 per month the -200SF used to command until late 2000, and is the rate operators will still be locked into. That is, the converted -400's rate of an additional $250,000 per month would have to be offset by savings in cash operating costs. I estimate the -400's cash operating costs are at least $1,200 per FH less than the -200SF's. The -400 will therefore be viable at utilisations of 375FH per month."

Characteristics

A 747-400 converted using an independent's STC would have a structural payload in the region of 225,000-230,000lbs. This compares to the factory-built aircraft's payload of 248,000lbs. A 747-400SF would have a lower structural payload than the -400F *(see table, page 46)* because it has a lower maximum zero fuel weight than the factory freighter and the passenger -400's wingbox is built for a lighter weight.

The section of main deck at the front that has to use eight-feet high containers underneath the upper deck will also be longer on the 747-400SF than on the -400F because of the converted aircraft has an extended passenger upper deck.

MD-11F, 747-200SF, 747-400SF & 747-400F PAYLOAD AND OPERATING COST CHARACTERISTICS

Aircraft	MD-11	747-200SF	747-400SF	747-400F
Maximum take-off weight lbs	630,500	833,000	875,000	875,000
Structural payload lbs	189,000	214,000	225,000	248,000
Containerised volume cu ft	20,116	26,683	25,800	26,947
Volumetric payload lbs (7lbs/cu ft)	150,800	200,000	193,500	202,000
Monthly lease rate $	450,000	300,000	550,000	900,000
Maintenance costs $/BH	1,440	2,200-2,450	1,850	1,670
Annual engine inventory costs $				
Annual flightcrew costs $	282,000	419,000	312,000	312,000

This means more pairs of eight-feet high containers must be used at the front of the converted aircraft's maindeck than on the -400F, making the 747-400SF's containerised volume about 800 cubic feet less than the -200SF's. Overall, the 747-400SF's containerised volume will be about 25,800 cubic feet *(see table, this page)*, also about 1,200 cubic feet less than the -400F's. The converted -400's volume shortfall could be alleviated by moving the upper deck floor beams forward, but will incur a high conversion cost to gain a small increase in container volume.

"The attractiveness of a converted -400 is affected by its payload characteristics and monthly lease rate," explains Alex Wecker, vice president of planning at Cargolux. "We would consider the 747-400SF at a lease rate of $550,000-600,000 per month, especially if there are no other aircraft types to consider. It is possible that a large number of -400s coming onto the market and getting converted would lower the production rates of -400Fs, making it hard for Boeing to continue production. This would leave conversion of -400s as the only option for acquiring aircraft of this size. The -400SF, however, has the disadvantages of the lack of a nose door and lower structural payload. The aircraft would still have to be flown at about 400FH per month to get a finance cost of $1,300 per FH. The financing rate would have to be about half what is paid for the -400F to make up for the -400SF's drawbacks. We prefer factory -400Fs because we need all its payload capacity."

Despite a difference of about 23,000lbs in structural payloads, packing densities of 7.5lbs per cubic foot mean that the volumetric payload of a fully loaded -400F will be about 202,000lbs; 46,000lbs less than the structural payload. The -400SF's and -200SF's volumetric payloads will be about 193,500lbs and 200,000lbs respectively. The converted and factory-built aircraft will therefore have a difference of about 8,000lbs in volumetric payloads.

The 747-400SF's range performance is expected to be 500nm less than the -400F and about 1,000nm more than the -200SF with the same payload. The -400F can carry 160,000lbs about 6,500nm, and so the converted aircraft is expected to have a performance of about 6,000nm with the same weight. This makes the 747-400SF suitable for trans-Pacific routes, which are the critical sectors for the aircraft to have widespread appeal. Despite a small range disadvantage, the 747-400SF will have almost the same volumetric payload and lower financing costs than the -400F.

The 747-400SF will have slightly higher cash operating costs because the older aircraft have higher maintenance costs. Although new aircraft have a maintenance 'honeymoon', aircraft still require reserves for D checks and engine shop visits. The new aircraft's reserves will be lower because its first D check consumes less man-hours and materials than the converted aircraft's third or fourth D checks. The new aircraft's engines also have longer on-wing runs and smaller shop visit workscopes than engines on older aircraft. New aircraft will also benefit from warranties on rotables and components in the first few years of operation. The older converted aircraft will also have higher engine inventory costs because of shorter on-wing runs than a new -400F.

Besides higher maintenance and engine inventory costs, the 747-400SF and -400F will have virtually identical cash operating costs for the same payload and route. The converted aircraft will therefore have the overiding operating cost advantage because of its lower financing charge. Not only will this allow the 747-400SF to carry almost the same payloads as the -400F for a lower trip cost, it could also put the converted aircraft in the position of carrying similar payloads at a lower or similar cost to the -200SF. The 747-400SF would thus be the most economic of all 747 freighter models where the -400F's higher payload is not required. The MD-11 will have lower trip costs, and so be the more economic option where its capacity is sufficient for a route's traffic density. Higher volumes will be carried more economically by the 747-400SF.

Economic performance

Because the 747-400SF's payload and range performance sits between the MD-11 and 747-200SF, and 747-400F, the economics of the four aircraft have to be analysed by illustrating how the performance of each varies with different loads, sector lengths and levels of aircraft utilisation and productivity. The MD-11 will generate a higher gross profit for a low payload volume because of its lower trip cost, but a 747-200SF, 747-400SF or -400F will be more economic where volume exceeds the MD-11's capacity.

An analysis of gross profit performance variation with daily route traffic volume, or payload load factor, will reveal which aircraft has the best performance for different payloads *(see charts, page 47)*. This assumes airlines will add an additional frequency on a route when average payload load factor has reached 90%.

Since aircraft performance is sensitive to finance costs and aircraft utilisation, and freight airlines achieve varying levels of utilisation and have different route lengths, this analysis can be made for different route lengths. Route length also affects available payload performance of each aircraft.

Longer routes and higher utilisation favour aircraft with the best payload-range performance and high finance charges, such as the 747-400F. Performance of the 747-400SF would only be adversely affected if a long route length gave it a payload disadvantage against the -400F. Shorter routes and lower levels of utilisation will make it easier for the MD-11, 747-200SF and 747-400SF to compete.

This analysis covers the four types with the specifications, freight capacities and volumetric payloads and operating costs shown *(see table, page 46)*. The addition of a frequency at 90% load factor means the 747-400SF will operate a second frequency with loads higher than 172,000lbs *(see charts, page 47)*.

The 747-200SF used in this analysis is based on a JT9D-7Q/-7R4G2-powered or CF6-50-powered aircraft with a maximum take-off weight (MTOW) of 833,000lbs.

The crucial factor for all aircraft types is monthly lease rate. The lease rates used for the MD-11F and 747-400F are close to the higher rates that were gained prior to late 2000 or early 2001. The rate for the 747-400SF is expected to be achieved by lessors in a stable market. This is because only a few deals will be struck at lower distress levels for a short period, while most leases will be agreed during the longer periods of stability. The 747-400SF is also likely to enter the market in early 2004, when stability is likely to have returned. One caveat is that lease rates for the MD-11 could be raised by 2004 because of a reduced supply of remaining aircraft.

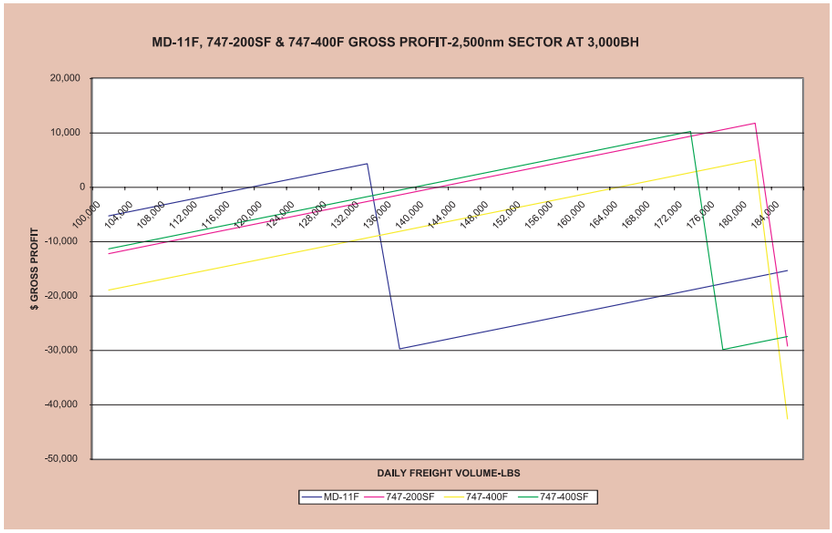
Lease rates for the 747-200SF were in the region of $450,000 prior to late 2000 and have fallen to about $275,000 due to market distress. Although the rates used for the other aircraft assume market stability, the -200SF's rates will be pushed down by the arrival of the 747-400SF on the market. A rate of $300,000 has therefore been assumed for the 747-200SF, on the basis that the 747-200SF will be at distress levels with the arrival of the 747-400SF on the market. The analyses thus only consider 747-200SFs that may be available on the market. The analyses do not consider the economics of a bought and converted 747-200s, which would require a higher lease rate.

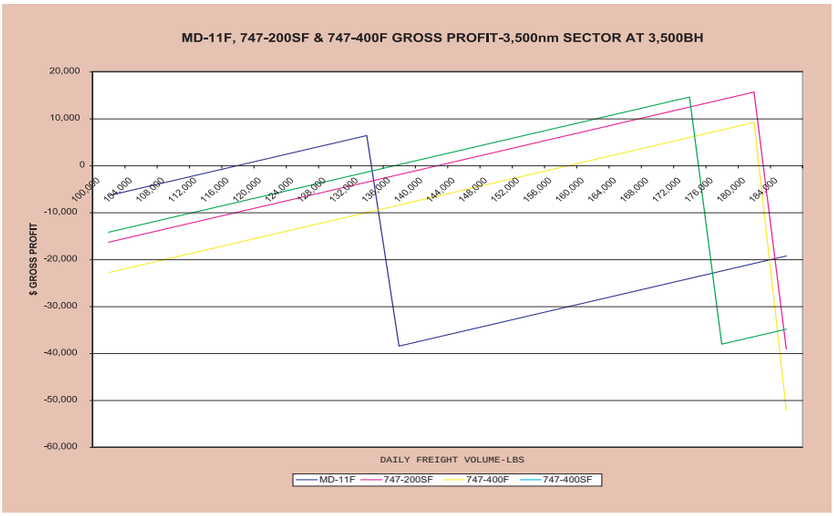
The gross profit performances of the aircraft have been compared against payload and generated revenue. The performance of the aircraft has also been analysed with varying utilisation, and aircraft productivity.

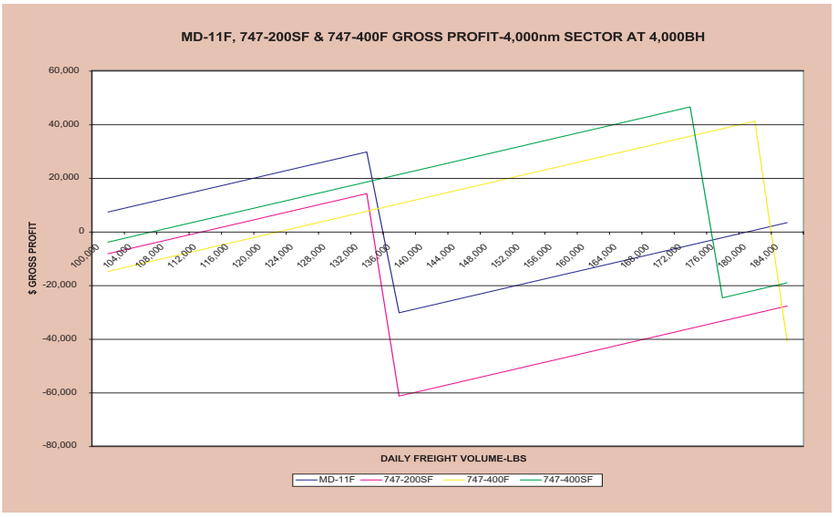
The three sector lengths and rates of block hour (BH) utilisation used are:

- 2,500nm & 3000BH
- 3,500nm & 3,500BH
- 5,000nm & 4,000BH

The different levels of utilisation and sector length influence the number of annual ton-miles generated by each aircraft. Sector length also affects payload performance, since structural payload reduces with longer sectors. Some aircraft may therefore be prevented from carrying a maximum payload on longer sectors, thereby limiting their ability to generate revenue and putting them at a disadvantage to aircraft with better payload-range performance. The effect is less marked with low packing densities, since volumetric payload is lower than structural payload for the same volume *(see table, page 46)*, and the aircraft's range is longer with this volumetric payload.







A packing density of 7.5lbs per cubic foot results in volumetric payloads of about 151,000lbs for the MD-11, 200,000lbs for the 747-200SF, 193,500lbs for the 747-400SF and 202,000lbs for the 747-400F *(see table, page 46)*. There are no restrictions or limitations in volumetric payload for any aircraft on the longest sector of 5,000nm, except for the 747-200SF which has its payload limited to 150,000lbs.

As well as lease rate, insurance and aircraft productivity, the cash operating costs of maintenance, engine inventory, fuel, landing and navigation, and flightcrew charges also have significant effects.

The maintenance costs used for each

Major freight carriers are faced with the prospect of a gap opening between the MD-11 and 747-400F. The 747-400SF would be a strong 747-200SF replacement candidate.

type *(see table, page 46)* based on airframe and component costs per FH are:

- $900 for the MD-11
- $1,350 for the 747-200SF
- $1,150 for the 747-400SF
- $1,050 for a new -400F.

The $100 difference between the two -400 models is mainly due to additional man-hours and materials for D checks of the converted aircraft.

The reserves per engine flight hour (EFH) used are:

- $180 for the MD-11
- $210-275 for the 747-200SF
- $175 for the 747-400SF
- $155 for the 747-400F.

Rates for the -200SF are particularly variable, since there is high variance between different JT9D variants and the CF6-50 tends to have lower reserves. The analyses assume mature maintenance costs for the 747-400F, so ignoring the effects of warranties on rotables.

Engine inventory costs are based on airlines owning sufficient engines to maintain a 50% confidence level for a fleet of five aircraft. Depreciation costs for these owned engines, in each operating scenario, are based on depreciation to zero at 7% interest. This is over six years for the 747-200 engines, 11 years for the MD-11 and 747-400SF engines and 17 years for the 747-400F.

Remaining requirements for spare engines are solved by leasing for multiples of 30 days. These are at daily lease rates of $1,700 for 747-200 engines and $3,000 for all other powerplants. Reserves are also paid for these engines, at the rate of $275/EFH for 747-200 engines and $250/EFH for all others.

Landing fees have also been used at a rate of $5 per ton of MTOW. Navigation charges are assumed at a rate of 20 cents per nm multiplied by the MTOW factor. MTOW factor is the square root of the MTOW in tonnes divided by 50.

Analysis

The three charts *(see table, page 47)* show the gross profit performance of the four aircraft types analysed for the three sector lengths and levels of utilisation described, using the freight yields discussed.

As expected the 747-400SF combines the advantages of low cash operating costs over the 747-200SF and the low financing or lease costs of a converted aircraft.

The MD-11, unsurprisingly, has the lowest trip cost in all three scenarios, resulting in it generating higher gross profits for smaller payloads *(see charts, page 47)*. Its trip costs of fuel, maintenance, flightcrew and lease costs are at least $1,000 less than the aircraft with the next highest costs.

The 747-400F has the highest trip cost in all three scenarios. Its cash operating costs are only marginally lower than the -400SF, as would be expected, because of the -400F's lower maintenance charges. The -400F is penalised by its higher finance charges. The differences between the -400SF and -400F are about $7,500 in the 2,500nm scenario, $8,600 in the 3,500nm case and about $11,000 on the 5,000nm sector.

This gives the -400SF a clear advantage over the -400F up to 172,000lbs, when two flights would be required to carry the load.

The 747-200SF has a higher trip cost than the -400SF in all three scenarios, despite its lease rate at distress values of of $300,000. This only in the order of $1,000 on the 2,500nm sector. This difference increases to about $2,000 on the 3,500nm route and rises up to $6,500 on the longest sector. This indicates that the 747-200SF will be forced out of the market by the -400SF, since the -200SF's lease rate will have to drop to distress levels for it to continue to be viable.

The 747-400SF has the lowest trip cost of all three 747 variants in all three scenarios.

This gives a clear indication that the 747-400SF generates the highest gross profit on payloads larger than 132,000lbs and up to 172,000lbs. The -200SF and -400F are only required for payloads higher than 172,000lbs, or even 190,000lbs if operators are not concerned about the possibility of 'spill' at 100% load factors. The -200SF's and -400F's volumetric payload advantage over the -400F is less than 10,000lbs, however.

The -200SF has a lower trip cost than the -400F, explained by its low lease rate more than offsetting its higher cash operating costs. The -200SF is therefore a better aircraft than the -400F, but only where its payload is not limited by route length, and acquired at distress lease rates. The -400F would provide a more economic solution when the rates the -200SF could attract two or more years ago were paid. In the case of a 5,000nm sector, the -200SF's payload is limited to about 150,000lbs, leaving the -400SF and -400F to carry higher loads *(see third chart, page 47)*.

Summary

The economic analysis clearly shows that the 747-400SF is the most economic solution for loads higher than 135,000-150,000lbs, except in the extreme cases where the -400F's additional 8,000lbs payload capacity is essential *(see charts, page 47)*. This is for a lease rate of $550,000 used for the -400SF.

The larger difference in trip cost and small difference in volumetric payload between the -400SF and -400F indicates the -400SF would still provide a more economic solution than the -400F if the -400SF had a lease rate of $650,000. Conversions would be viable for a total build cost of $50-55 million. AC