Some airlines have long since replaced their DC-9 & 737-200 fleets, while others still acquire more. Seven aircraft families stand as potential replacements, but only certain economic and operational circumstances make a case for displacing the die-hard narrowbody workhorses.

How & when can the DC-9 & 737-200 be replaced?

Nothing has perhaps been more astounding than the tenacity of the DC-9. Aircraft more than 30 years old are still operated by major airlines. Even the younger and more advanced 737-200 has not remained as popular with the major airlines.

The DC-9 and 737-200 can provide operators with 72–122-seat aircraft with attractive operating costs and the ability to conform to all environmental rules. Some of the last of the DC-9's and 737-200's largest supporters are making selections to replace their fleets, while others are still operating or even acquiring more aircraft.

DC-9 & 737-200 in operation

There are still about 830 737-200s and 570 DC-9s in passenger operation.

The DC-9 fleet is 18–33 years old and includes aircraft operated by Aerocalifornia, Aeromexico, Air Canada, Airtran, Finnair, Hawaiian, Iberia, Midwest Express, TWA and USAirways. The largest and best-known fleet is Northwest's 170 aircraft.

The 737-200 is 13–31 years old. The major 737-200 fleets are operated by Aerolineas Argentinas, Air Algerie, Air France, Air New Zealand, Air Philippines, Alaska Airlines, Aloha Airlines, America West, British Airways, Canadian Airlines, Delta, Frontier, Lan Chile, Olympic, Ryanair, Southwest, USAirways, Varig, VASP, and Westjet.

The majority of DC-9s and 737-200s are flown on the lowest density short-haul route networks of major and secondary scheduled airlines. These networks include route lengths in the region of 250–650nm. Examples are Air Canada's network from Toronto to other east Canadian cities and destinations in the north-east US.

70–125 seat markets

The DC-9 and 737-200 have traditionally filled the roles of operating the lowest density and shortest routes operated by major carriers.

Styles of operation changed with the advent of smaller jets and operations by regional subsidiaries. The CRJ and ERJ-145, for example, have provided airlines with smaller aircraft which make lower density routes more viable and higher frequencies and new direct services possible on other services.

This is illustrated by the opening of a large number of new routes by carriers such as Comair with a new route from its Cincinnati hub. The knock-on effect has been to stimulate traffic. As these routes grow then larger aircraft approaching the size of the DC-9-10, -20 or -30, have become necessary. It is possible, therefore, that the DC-9 and 737-200 could be replaced with smaller types, or with a mixture of aircraft of a variety of sizes to better match an operator's requirements.

The ERJ-170/-190, for example, are targeted at the growing regional markets. New regional subsidiaries with lower staff costs and overheads are being formed to use regional jets.

The issue of DC-9 and 737-200 replacement is not therefore simply a case of one-for-one substitution in the same markets, but also one of providing regional aircraft families which offer more opportunities through flexibility while remaining economic.

Size limits

Opening new route networks with regional jets is often made difficult by pilot unions in the major airlines.

The transfer of lower density routes to subsidiaries and franchise partners is the key to finding a role for regional jets. This is prevented through the use of scope clauses by pilot unions. Scope clauses limit the number and size of jets operated by partner carriers. The size of regional jets that the most scope clauses allow is 50 or 70 seats.

Replacement candidates

There are seven basic types on offer to replace the DC-9-30/-50 and 737-200.

The first three major types are the A318/19, 717 and 737-600/-700. In a standard two-class configuration the DC-9-10/20 has 72 seats. The DC-9-30, the most numerous of DC-9 models, has 97 seats. The larger -50 variant has 122. The 737-200 has 108 seats.

The A318, Airbus' latest A320 family model, has 107 seats and the A319, 124. These two aircraft also have two larger family members, the A320 and A321, offering up to 186 seats, and thus wide-ranging commonality benefits across a large family.

The A318/19 models are DC-9-30, -50 and 737-200 one-for-one replacements. Their advantages are the already high degree of market penetration made by the A320 family market. A large number of DC-9 and 737-200 operators have already selected the A320 family. This includes Northwest, Air Canada, USAirways, United, British Airways, Air France, Iberia, Alitalia, Finnair, America West, Canadian and Frontier.

The majority of major airlines that have made DC-9 & 737-200 replacement decisions have selected aircraft from the A320 family. SAS is the only carrier to select the 737-600 and a handful have ordered the 717.

The A320 family is established as an efficient aircraft. Its extensive commonality, especially its cross-crew qualification, has given airlines the scope to benefit from savings over older fleets. Airbus has the reputation, however, of having won many sales campaigns in recent years through aggressive price discounting which other manufacturers were not willing to consider.

The A318 has the disadvantage of being heavy for its weight *(see table, page 19)* and so inherits the fuel burn characteristics of its larger sisters. High weight will also be a disadvantage in the European market because of expensive weight-related charges.

Because the A318 is a derivative of the A320, it also has similar maintenance cost characteristics to larger aircraft.

The 717 is an autonomous model offered by Boeing, with 103 seats. It is a high derivative of the DC-9. The 717 has a modern flightdeck and BR715 engines, which are considerably more fuel-efficient and have lower maintenance costs than the DC-9's or 737-200's JT8D. The 717, however, lacks family commonality size flexibility. It is expected to have the DC-9's durability and so steady maintenance costs.

The 717 has so far only managed to win orders from a small number of DC-9 or 737-200 operators. These include Airtran, TWA and Hawaiian.

For larger types and family appeal Boeing has the 737-600 and -700. The -600 is just five seats larger than the 717, although the 737-600 is heavier. The appeal of the 737-600/-700 is similar to the A318/19/20 in terms of family flexibility. Although it has won large orders, the 737-600/-700/-800/-900 family has lost a lot of customers to the A320 family. SAS is the only major DC-9 or 737-200 operator to have opted for the 737-600 as a replacement.

Dividing line

There are also smaller regional jets the size of the DC-9 family and 737-200A from Avro, Fairchild, Embraer and Bombardier.

The manufacturer that has made most progress is Embraer. It launched the ERJ-170/-190 in mid-1999 and has already gained 60 firm orders from Crossair. Embraer has won large market share in the overall regional market in the past five years, assisted by its competitive list pricing and the aid of Proex financing subsidies. It is also due to the fact that the size of its smaller jets meets with the constraints of scope clauses.

The ERJ-170 has 70 seats. However, Embraer's real DC-9 and 737-200 replacement candidate is the ERJ-190-100 and -200 with 92 and 100 seats in a two-class configuration. These two models are well placed in terms of seat numbers, the ERJ-190-200 being the largest of the jets from all four regional aircraft manufacturers. The ERJ-170-190 are lightweight and have sufficient range performance, and so possess all the basic qualities to make a good candidate.

Avro is now offering the RJX series, the second derivative of the BAe 146. Avro seems to have an aircraft with appreciable qualities, now that it has selected a powerplant which will match the on-wing reliability and fuel burn performance of modern jets. The RJX-100 can seat up to 100 passengers in a two-class configuration, making it large enough directly to replace the DC-9-30 and 737-200. Like Embraer, the smaller RJX variants can offer aircraft with smaller seat numbers to those airlines that want flexibility.

The RJX is also one of the lightest of the seven aircraft family choices, giving it an advantage in all potential markets. It has the added bonus of superior field performance in the order of 1,200–3,200 over similar-sized competitors.

The Fairchild 728Jet and 928Jet have had limited success, with only the 728Jet having one firm order. The 928Jet is yet to be launched but offers airlines with a 98-seat capacity aircraft with competitive weight, range and field performance.

Bombardier is running fourth. It has proposed developing a second stretch of the CRJ: the 90-seat CRJ-900. It is further proposing an all-new aircraft: the BRJ-110.

The CRJ-900 is light for its size, benefiting from its derivation from the CRJ. It only offers four abreast seating, which many airlines may find hard to offer passengers who are accustomed to DC-9 or 737 service. The CRJ-900 also only has two main doors, which restrict its cosmetic appeal as a non-regional jet.

On paper the BRJ-110 is the better DC-9 and 737-200 replacement candidate, in that it will offer airliner-style cabin size and door numbers, will have 108 seats and will be light compared to the alternatives.

Economic issues

The main developments in improved aircraft operating costs since the advent of the DC-9 and 737-200 have been fuel efficiency, lower crew costs due to increased automation, reduced maintenance, improved system and engine reliability and reduced training and inventory through commonality.

Not all airlines feel the need to replace their DC-9s or 737s. One example is Milwaukee carrier Midwest Express. The airline operates a small fleet of DC-9-10s and -30s with a four-abreast cabin, serving the business market.

The airline incurs high total costs of 11–12 cents per available seat-mile (ASM) through having just 84 seats in its DC-9-30s and offering restaurant service meals.

Frontier made an economic case for replacing its 737-200s on the basis that it has a high utilisation operation, with 850nm sectors and 3,900FH per year. This allowed it to absorb high finance charges of new aircraft and it selected the A318 and A319.

"Our aircraft are hushkitted 1965–80 vintage and we could not operate this strategy with new aircraft," explains Dennis O'Reilly, treasurer at Midwest Express. "We have looked at the A318, but it has too wide a cabin for our service. Only the 717 makes sense in this respect. The aircraft does have lower cash operating costs than the DC-9, but also higher finance charges. Because of this we cannot make sense of flying new aircraft which would have four or five times the capital cost of used ones".

Vanguard and Westjet are two other North American operators that have increased their fleets of used aircraft; in this case the 737-200. Others, such as Frontier and TWA have made the decision to acquire new aircraft.

Operating cost elements

To assess the economics of the DC-9, 737-200 and their replacements, five operating cost elements can be studied in turn. These are: fuel, maintenance and spare parts, airport and air traffic user charges, flight crew and aircraft finance and depreciation.

These should all be assessed on the typical route lengths the aircraft will fly in a North American or European short-haul operation in a two-class cabin configuration. These routes will be 250–650nm in most cases, while seat numbers will be as shown *(see table, page 19)*.

Patterns of operation in North America will be mainly hub and spoke, although larger numbers of carriers operate point to point services. European airlines stay more in line with point-to-point services.

Hub operations mean the pattern of aircraft utilisation will be a fixed number of daily and annual cycles with varying sector lengths. ASMs generated will therefore depend on average sector length, which, for the DC-9 and 737-200, is likely to be 450nm, an 80-minute flight time.

An average of five flights per day will then generate about 2,400 flight hours (FH) and 1,800 flight cycles (FC) per year. Because of higher maintenance requirements and reliability it could be assumed that the DC-9 and 737-200 only achieve four flights per day. This reduces their utilisation to 1,920FH and 1,440FC per year.

Point-to-point services in North America and Europe could still have average sector lengths of 450nm. Average turn times between flights of 60 minutes would still only allow five flights a day.

Fuel

The 737-200 and DC-9 series have fuel burns which at a cost of 60 cents per US gallon translate into cents per ASM of 1.50 and 1.5–1.95, respectively.

The 717, 737-600/-700 and A318/319 have fuel costs of 1.24, 1.0–1.3 and 1.06-1.17, respectively, per ASM. The fuel efficiency of these aircraft is not large enough to make new aircraft more attractive.

As would be expected, the regional jets have higher c/ASM fuel costs. The RJX family has costs of 1.15–1.50 c/ASM, while the equivalent-sized twin-engined aircraft are about 0.1 cents per ASM more efficient. The 70-seat aircraft have costs of about 1.4 cents, although there is variation according to weight. The 90-seat aircraft have costs of about 1.3 cents and the 100-seat models nearer 1.2 cents.

Maintenance

Maintenance costs and spare parts inventory is one area where new aircraft can make a large impact. Increasing defect ratios raise manhour (MH) consumptions, ageing components degrade reliability and raise repair costs and older generation engines have short on-wing times. New aircraft have warranties, low defect ratios and simplified maintenance programmes and engines that can achieve on-wing times two or three times as long as the DC-9's and 737-200's JT8D.

The 737-200 has airframe and component maintenance charges in the region of $650 per FH. Additional costs for the JT8D will be about $120 per engine FH (EFH), taking total aircraft maintenance costs to about $900 per FH. This includes the cost of accessing spare components, but not engine inventory.

Maintenance costs for the DC-9 will be close to the 737-200. The DC-9 has the same engines as the 737-200, while the DC-9 will also have similar airframe and component repair charges.

The 717 would be expected to have similar airframe and component costs to the DC-9, although the 717 would of course have lower costs and operators might expect about $550–600 per FH. The engine maintenance costs are also difficult to estimate at this stage of the aircraft's operation. Considering the CFM56's costs, a rate of $95 per EFH for the BR715 would provide an operator with a budget. This would take the aircraft's total costs to $790 per FH.

New aircraft will have the opportunity of lower maintenance costs from several aspects. The 737-300/-400/-500 series, for example, has airframe and component charges in the region of about $480 per FH. This comes from airframe checks costs being about $100 per FH lower for the younger aircraft, while saving about another $60 per FH on component costs.

The 737-600/-700 is expected to have about 10% lower maintenance charges throughout, because of a simplified maintenance programme and fewer parts. Airlines might then expect airframe and component charges for the 737-600 to be about $440.

The CFM56-3 series can have shop visits costs that average about $110 per EFH, and so will only actually have costs about $20 per FH lower than the JT8Ds on the 737-200 and DC-9. This is explained by there being a large number of JT8D parts on the market. The CFM56-7 is, however, expected to achieve better reliability than the CFM56-3. Engine maintenance costs could then be reduced by about another $30–40 per FH for the aircraft. Overall, the 737-600's/-700's maintenance charges could total about $440 per FH for airframe and components and $220 per FH for engines; a total of $660 per FH. This compares to $900 per FH for the DC-9 and 737-200.

The A320 family aircraft have airframe and component maintenance costs of about $500 per FH. The CFM56-5B series has costs of about $120 per EFH. Thus the A318/319 will have total maintenance charges in the region of $740 per FH. The PW6000 on the A318 might be expected to have lower maintenance charges, and this may reduce total aircraft maintenance costs by $20–30 per FH.

Engine costs for the twin-engined regional jets are expected to be $80 per EFH and so $160 per FH. The RJ-X's smaller powerplants might be expected to have costs of $65 per EFH, but because of its four engines a cost of $260 per FH. Because of the smaller size of regional jets compared to the larger aircraft, the former could then be expected to have airframe and component costs in the region of $350 per FH. This would take total RJ-X costs to $610 per FH and the other three major types to $510 per FH.

Regional jet maintenance costs would then be 1.4–2.6 cents per ASM, depending on size of the variant being analysed. The new large jets would have costs of 1.5–2.3 cents per ASM.

The 737-200 has costs of 2.45 cents per ASM and the DC-9 series 2.3–3.7 cents per ASM.

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Aircraft	DC-9-10/-20	DC-9-30	DC-9-50	737-200A
Seats (F/Y)	72	97	122	108
MTOW lbs	98,000	105,000	121,000	128,000
Typical lease rate $	50,000	70,000	90,000	105,000

Aircraft	717	737-600	737-700	A318	A319
Seats (F/Y)	103	108	128	107	124
MTOW lbs	121,000	145,000	155,000	145,500	162,000
List price ($ million)	33	40	45	36	45

Aircraft	RJX-70/85/100	728/928Jet	ERJ-170/190	CRJ-900
Seats (F/Y)	70/85/100	63/98	70/92/100	90
MTOW lbs	95,000/ 97,000/ 101,5000	82,673 104,058	79,343/ 105,798	82,500
List price ($ million)	25.5/27.4/29.9	20/23.5	21/24/25	29

Flight crew

Only aircraft size and flight crew commonality will allow new aircraft to make an impact over the DC-9 and 737-200.

Flight crew salaries can be based on aircraft size or gross weight. In the case of regional aircraft flight crew salaries will be lower in partner airlines or subsidiaries purposefully set up to operate regional jets.

Commonality with other types, leading to mixed fleet flying and reduced training can result in large savings not currently possible with autonomous DC-9 and 737-200 fleets.

Of all modern types analysed here, it is assumed crews achieve an average of 700FH per year productivity, while DC-9 and 737-200 crews only generate 650FH per year. In a real airline situation this difference will depend on the other types operated by the airline and its mixed fleet flying policy. There may actually be no difference between types.

Because of common type ratings among aircraft families, most airlines will pay the same salaries to pilots flying different variants. A318 pilots, for example, will therefore receive the same salary as A320 pilots of the same rank.

Captain salaries for the four regional jets are assumed to be $70,000 and first officer salaries $45,000.

These rise to $130,000 and $90,000 for 737 crew and even higher to $145,000 and $100,000 for A320 family crew. The discrepancy between the 737 and A320 families is based on current differences between airlines that operate these types. In a case where an airline replaces DC-9s or 737-200s with either 737-600/-700s or A318/319s, higher salaries are unlikely to be paid to the A318/19 crew in some airlines in the event of selection.

Although other costs for training, subsistence and allowances are incurred for flight crew, they are not analysed here. Commonality in modern families will allow savings in training costs to be made.

The result is a polarisation of crew costs per ASM between regional jets and the larger jetliners. The RJX, 728/928Jets, CRJ-900 and ERJ-190-100/-200 have costs in the order of 0.45–0.54 cents per ASM. This compares with crew costs of 0.70–0.97 cents per ASM for the DC-9, 737s and A318/19.

In the two groups, aircraft with the largest number of seats benefit the most. The ERJ-190-200 has the lowest costs and the CRJ-900 slightly higher charges. Likewise, the 737-700 has the lowest costs and the 717 the highest.

The difference between these two groups illustrates the cost differences between major carriers and their regional affiliates.

User charges

Weight-related user charges are low in the US and are only charged at an average rate of $2.2 per tonne of maximum take-off weight for landing. This rate rises to $9 per tonne in Europe, where navigation charges are also incurred. These are the product of $1 multiplied by the distance multiplied by the square root of the MTOW divided by 50.

Operators such as Midwest Express and others like Vanguard and Westjet have opted to keep their DC-9 & 737-200 fleets. In several cases more used aircraft are being acquired. It is hard to make an economic case of replacing fully depreciated DC-9s and 737-200s on operations with typical utilisations.

The unit costs for landing in the US are 0.20–0.30 cents per ASM, depending on aircraft type. This narrow cost range shows aircraft type is not important in this respect in the US market.

Combined landing and navigation charges in Europe are much higher, at 1.6–2.3 cents per ASM. While these charges are higher, the differences between types of a similar size are not enough to make an impact on aircraft selection.

Finance & depreciation

Finance charges are the largest cost element. Many DC-9s and 737-200s are owned and fully depreciated while still having competitive cash operating costs. This makes it even harder for airlines to justify acquiring new aircraft. "New aircraft have higher finance and insurance costs," explains O'Reilly at Midwest Express. "There is nothing from a structural or environmental point of view that forces us to replace our aircraft. Only regulation of an issue such as Stage 4 noise compliance will make us take new aircraft. Their economics are not overwhelmingly bad at the sort of discounts we could get, but they would not generate any more revenue than our current fleet. From this point of view it is not worth having the much higher capitalisation in the company".

The implications of aircraft ownership costs can contrast between carriers. "We do not own any of our aircraft, but rather lease them", says Sean Menke, director of planning and scheduling at Frontier Airlines. "We operate average sector lengths of 850nm with our 737-200As and have an average utilisation of 3,900FH per year.

"Our unit cost is about 7.95 cents per ASM. We found that when we looked at new aircraft such as the 737-600 and -700, their lower cash operating costs could offer lower total costs. This led us to analyse the A318 and A319, which we selected", continues Menke. "We expect to see a reduction in our unit cost with the A318 and A319. This is explained by us being able to dilute the high finance charges of new aircraft over a high rate of utilisation."

Most airlines are able to acquire a 20% purchase discount on the manufacturer's list price and will have a lease rate factor of 1.05%. Airlines in the US are able to get lease rate factors as low as 0.90%.

Lease or depreciation rates for the DC-9 and 737-200 will vary, according to ownership, degree of depreciation and Stage 3 modification status. Finance charges are zero for some carriers. Lease rates for airlines locked into leases of Stage 3 aircraft will be about $50,000 for the DC-9-10/-20, $70,000 for the DC-9-30, $90,000 for the DC-9-50 and $105,000 for a 737-200A.

Finance charges for the DC-9-10/-20, -30 and -50 will be about 1.29, 1.34 and 1.37 cents, respectively, per ASM and 1.80 cents for the 737-200A.

Commensurate with the levels of utilisation achieved, the new aircraft have finance and depreciation charges in the region of 3.00–4.60 cents per ASM, depending on aircraft type, size and pattern of operation.

For the same style of utilisation, the ERJ-190 has the lowest charges for finance, illustrating Embraer's characteristic if competitively priced aircraft, even without the advantageous effects of Proex. The ERJ-190-200 has a finance charge of about 3.1 cents, which rises to 3.25 cents for the ERJ-190-100. The 928Jet has a similar cost, while the RJX-100 has a higher rate of 3.7 cents.

Despite their size, the A318, A319, 717 and 737-600/-700 have higher charges, in the order of 4.0–4.6 cents per ASM. This is explained by the fact that they are members of larger families with more capability. The unit finance charges nevertheless illustrate that the larger aircraft are relatively expensive compared to their seat numbers.

Total costs

The costs studied here form a generic analysis, rather than looking at specific geographic markets. The only specific charge examined on a geographical basis are the user charges. Finance and flight crew charges are based on monthly lease rate factors of 1.05% and the average of West Europe and North American flight crew costs.

With US user charges, the 737-200 has total costs of 6.8 cents, while the DC-9 series has costs of 6.1–8.4 cents. This is for aircraft which are acquired under leases *(see chart, page 21)*. Owned and fully depreciated aircraft have costs that are 1.3–1.8 cents per ASM lower.

The direct new replacement candidates have costs of 7.7–8.6 cents per ASM. The largest, the 737-700, has the lowest rate, while the 717 and A318 have the highest. These costs are not too dissimilar to those of the 737-200 and DC-9 series. Although the A319/737-700 have high acquisition costs their total cost are 1.6–1.9 cents per ASM higher than a leased DC-9-50. The A318/717/737-600 have costs about 1.7 cents per ASM higher than the 737-200/DC-9-30.

The total costs shown for aircraft types rise by 1.7–2.0 cents per ASM in the European scenario because of higher landing and navigation charges.

The option of regional aircraft provides some competitive costs per ASM. The RJX-100 has total costs in the region of 7.7 cents per ASM in a US scenario, while the 98-seat 928Jet and 100-seat ERJ-190-200 have costs of 6.5 cents per ASM. The economics of these

100-seat regional jets compare with total charges of 6.8 cents per ASM for the 737-200/DC-9-30 *(see chart, page 21)*.

The 72-seat DC-9-10/-20 also have good replacement candidates in the RJX-85 and ERJ-170 which have total costs of 8.1 cents per ASM. This compares with 8.4 cents per ASM for leased DC-9-10/-20s with the same pilot salary scales as the larger DC-9-30 and -50 models.

Summary

This analysis reveals that despite having high acquisition and finance charges new aircraft can offer airlines replacement aircraft with total costs in the region of 1.0–1.5 cents per ASM higher than leased 737-200s and DC-9s. The challenge to offer better economics will be higher for new aircraft in the case where the 737-200 and DC-9s are owned and fully depreciated, which have 1.3–1.8 cents per ASM lower total costs.

The 1.0–1.3 cents per ASM cost difference is only achieved with the DC-9 and 737-200 operating at 25% lower utilisations than new counterparts. Carriers, such as Frontier, achieve at least 50% higher rates of aircraft productivity than those used here for the 737-200A. This demonstrates that in many cases airlines can make an economic case out of acquiring new aircraft to replace the DC-9 and 737-200A with new equivalent sized jets.

Airlines will eventually have to acquire new aircraft and accept an increase in total costs per ASM. The difference in unit costs between new and old will be reduced as maintenance costs of current fleets rise and components become harder to find or buy. The biggest threat to the 737-200 and DC-9 is still the possibility of further regulatory issues, such as Stage 4 noise or structural airworthiness directives.

In the case of regional jets, the superior economics of 70–90 seat aircraft makes a strong case for replacing the DC-9-10/-20. The 90–100 seat regional jets also have good economics compared to the DC-9-30. This is on the basis that airlines will be able to operate regional jets with flight crew salaries lower than the current rates used for the 737 and A320 families in major airlines.

This is, however, only in the case of the DC-9s being leased. Owned and fully depreciated aircraft which have been hushkitted and refurbished for an extended life will have lower unit costs than shown and so will be harder to replace.

The economics of regional and larger jets illustrates how airlines will want to explore the possibility of widening scope clauses or create special-purpose subsidiaries to operate the regional jets at a lower unit cost. AC