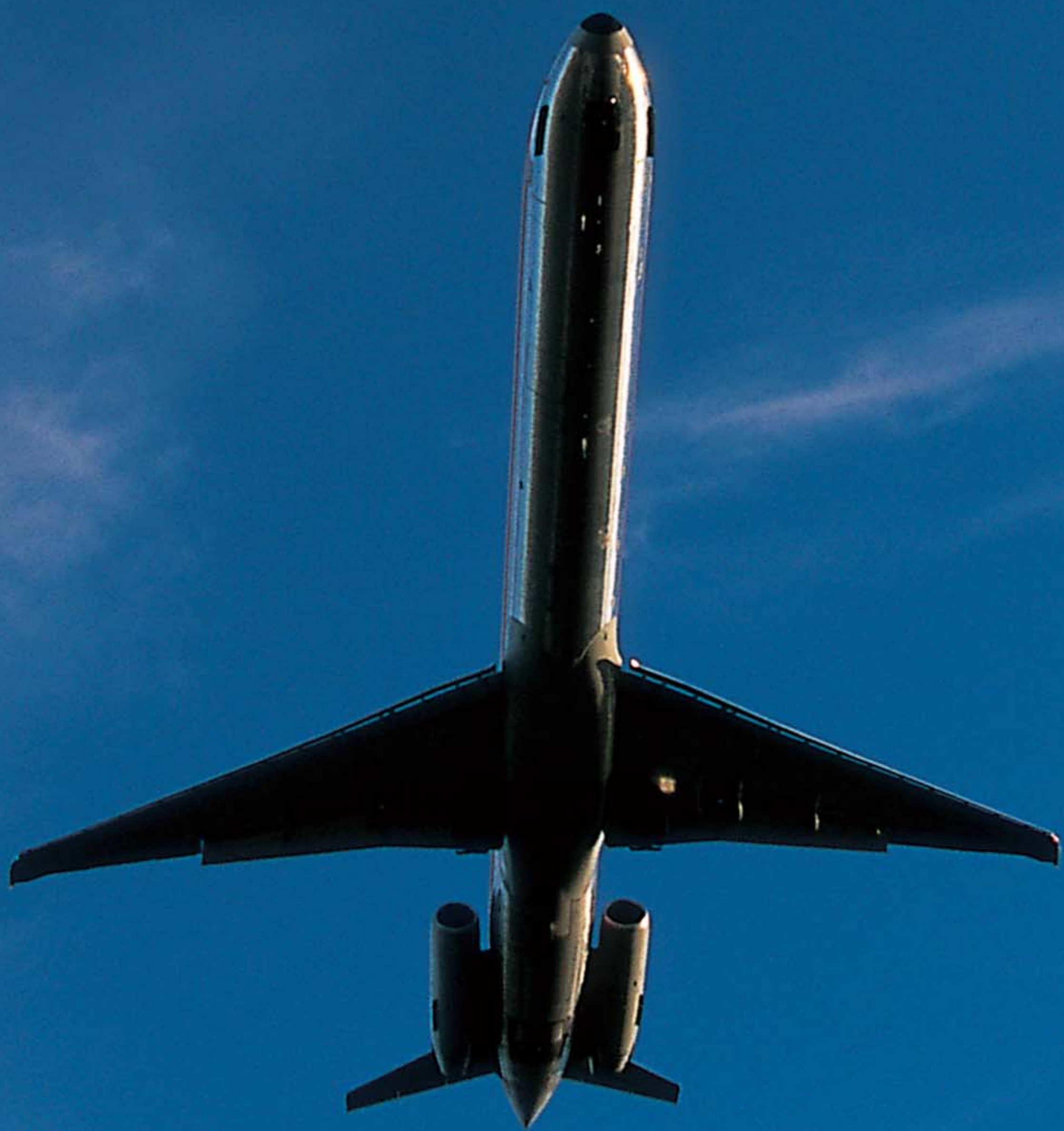
AIRCRAFT OWNER'S & OPERATOR'S GUIDE: MD-80 / -90



MD-80/-90 specifications

The MD-80 family & MD-90 have followed a simple course of evolution. Specifications for different variants are detailed.

A total of 1,194 MD-80s were built between 1980 and 1999. Only 117 MD-90s were manufactured between 1995 and 2000.

There are five MD-80 variants, while there is just one basic model for the MD-90. The MD-80 was first conceived in 1977 as a development of the DC-9-50, but it is in fact a sub-type of the DC-9, and does not have its own separate type certificate. The MD-80 was developed as a stretch development of the DC-9-50 with a 14-foot longer fuselage that allowed a higher seating capacity. The MD-80's other main changes were an increased wing span and higher thrust development of the JT8D engine: the JT8D-200 series. The MD-80 has a two-class seat capacity of 143. The MD-80 was initially developed with an analogue flightdeck.

MD-81

The first variant was the MD-81, and was launched by Swissair. The aircraft was powered by the JT8D-209 rated at 18,500lbs thrust. This was the first variant of the JT8D-200 series. The MD-81's standard specification was a usable fuel capacity of 5,840 US Gallons (USG), and the aircraft had a maximum take-off weight (MTOW) of 140,000lbs. Overall the specifications gave it a range of 1,400nm *(see table, page 11)*. Only 80 MD-81s were built, and included aircraft between line numbers 909 and 1,999built between 1980 and 1999.

These were the MD-81's initial specifications, and various improvements and modifications were later possible. A version with a MTOW of 142,000lbs was developed. This had the same -209 engines, but a longer range of 1,550nm *(see table, page 11)*. It also became possible to refit the aircraft with the higher rated JT8D-217 and -219 engines, rated at 20,000lbs and 21,000lbs thrust respectively.

MD-82

The MD-82 was a higher gross weight development of the -81. The main difference over the -81 was a higher MTOW of 147,000lbs. This increased gross weight was supported by higher rated engines at 20,000lbs thrust. Standard fuel capacity was the same as the -81's at 5,840 USG, giving the aircraft a range of 1,800nm *(see table, page 11)*.

There are three versions of the -217; the -217, -217A and -217C, the latter two having lower specific fuel consumption and so giving the aircraft marginally longer range up to 2,000nm. The -217A and -217C also have a higher flat rating and power the MD-82 with the higher MTOW of 149,500lbs.

Although the MD-82 fleet is dominated by -217-powered aircraft, there are also a few examples powered by the -209 and -219.

Production started in 1981 with line number 997 and continued until 1997 to line number 2,204, with a total of 603 aircraft being completed.

MD-83

The MD-83 is a higher gross weight and longer range development of the -82. The -83 is powered by the JT8D-219 rated at 21,000lbs thrust. The aircraft has a MTOW of 160,000lbs and is available with several fuel capacities. The first is the standard volume of 5,840USG, but there are three different variants of auxiliary tanks, allowing total fuel volumes of 6,405USG, 6,620USG and 6,970USG. This gives the aircraft a range between 2,100nm and 2,450nm.

Aircraft structure, landing gear, wheels and brakes were all strengthened to cope with the higher gross weight.

Production commenced in 1985 with line number 1,234 and continued until 1999 to line number 2,287 for a total production of 277 units.

MD-88

As part of the process of modernising the MD-80, McDonnell Douglas (MDC) offered it with a glass electronic flight instrument system (EFIS) display flightdeck together with a windshear warning system.

Besides the EFIS flightdeck, the MD-88 has the same weight, fuel capacity and range characteristics as the MD-82 and -83.

Production of MD-88s started in 1986 with line number 1,338 and continued up to line number 2,187 in 1997 after a total of 158 aircraft were completed. Some MD-88s, however, were not originally manufactured as -88s, but were upgraded MD-82s.

There are five main MD-80 variants. The most popular was the MD-82, with 603 being built. The MD-83/-88 has the highest performance, with a range of 2,450nm.

MD-87

The MD-87 is the only member of the MD-80 family to have a different sized fuselage. The aircraft has a 17-feet shorter fuselage, making it marginally shorter in length than the DC-9-50. The MD-87 has a two-class seat capacity of 117. The variant first entered service in 1987, and was developed as a response to the evolution of aircraft families that Airbus and Boeing began to propose at the time.

The MD-87 was powered by the JT8D-217 rated at 20,000lbs thrust and by the -219 rated at 21,000lbs thrust. The aircraft has several MTOW options, starting at 140,000lbs and increasing up to 149,500lbs. It also has several fuel capacity variants, ranging between 5,840USG and 6,970USG, which give the aircraft a range capability between 2,400nm and 2,850nm *(see table, page 11)*.

One small feature of the MD-87 was its 'beaver' tail cone, which was required because of the shortened fuselage. This type of tail cone has since been adapted by operators for use on the MD-81/-82/-83/-88 to lower drag.

Production of MD-87s started in 1987 with line number 1,326 and continued to 1,985 in 1999 for a total of just 76 aircraft.

MD-90 series

By the mid-1980s MDC was considering further evolution and development possibilities for the MD-80. Pratt & Whitney had both developed unducted fan and ultra-high bypass engines which were flown on MD-80 testbeds. These two engines achieved high fuel efficiency, but plans to use them were eventually dropped since their complexity and consequent high maintenance costs offset the savings made from reduced fuel burn.

MDC was also considering the new V.2500 being developed by International Aero Engines. The MD-90 was conceived in the late 1980s by marrying the MD-80's fuselage with with the V.2500. Delta Airlines placed an initial order for 50 aircraft in 1989. The first variant was the MD-90-30, and in fact had a 5-foot fuselage stretch over the MD-80. This gave the MD-90-30 a two-class seat capacity of 153. The 5-foot stretch allows two additional seat rows of economy seats thereby adding 10 seats.

The MD-90 has a MTOW of 156,000lbs and fuel capacity of 5,840USG, giving the aircraft a range of 2,270nm *(see table, page 11)*. It also has a flightdeck based on the MD-88's system, plus use of a flight management system and inertial reference system. The aircraft uses the V.2525-D5 rated at 25,000lbs thrust.

MDC had plans to offer an MD-90 family, and proposed a stretch variant (-40 series) and shortened variant (-10 series) to offer models with higher and lower seat capacities. Orders were not received for these. MDC later developed a higher gross weight version of the -30, the -30ER. This had a MTOW of 168,000lbs, fuel capacity of 6,405USG and range of 2,780nm *(see table, page 11)*. The MD-90-30ER is powered by the V.2528-D5 rated at 28,600lbs thrust.

Production of the first aircraft was in 1995 with line number 2,098 and continued until 2000 up to line number 4002 for a total production of 117 aircraft.

MD-80/-90 SERIES

Variant	MD-81	MD-81
MTOW lbs	140,000	142,000
Fuel volume USG	5,840	5,840
Engines	JT8D-209	JT8D-209
Seats (two-class)	143	143
Range-nm	1,400	1,550

Variant	MD-82	MD-82	MD-82/-88
MTOW lbs	147,000	149,500	149,500
Fuel volume USG	5,840	5,840	5,840
Engines	JT8D-217	JT8D-217A	JT8D-217C
Seats (two-class)	143	143	143
Range-nm	1,800	1,950	2,000

Variant	MD-83/88	MD-83/88	MD-83/88	MD-83/88	MD-83/88
MTOW lbs	160,000	160,000	160,000	160,000	160,000
Fuel volume USG	5,840	6,405	6,620	6,970	7,780
Engines	JT8D-219	JT9D-219	JT8D-219	JT8D-219	JT8D-219
Seats (two-class)	143	143	143	143	143
Range-nm	2,100	2,300	2,400	2,500	2,450

Variant	MD-87	MD-87	MD-87	MD-87	MD-87
MTOW lbs	140,000	149,500	149,500	149,500	149,500
Fuel volume USG	5,840	5,840	6,405	6,620	6,970
Engines	JT8D-217C	JT9D-219	JT8D-219	JT8D-219	JT8D-219
Seats (two-class)	117	117	117	117	117
Range-nm	2,400	2,400	2,650	2,700	2,850

Variant	MD-90-30	MD-90-30ER
MTOW lbs	156,000	168,000
Fuel volume USG	5,840	6,405
Engines	V.2525-D5	V.2528-D5
Seats (two-class)	153	153
Range-nm	2,270	2,780

Chinese production

In 1985 MDC agreed with Shanghai Aviation Industrial Corporation (SAIC) and China Aviation Supply Corporation (CASC) to produce 25 MD-82s under license in Shanghai, China. The first entered service in 1987.

Various other agreements were reached to build additional MD-82s, and in 1994 an agreement was made to build up to 30 MD-90s. Eventually 37 MD-82s/-83s and 22 MD-90s were built. These are operated by China Southern, China Northern and China Eastern. Some China-built aircraft have since been acquired by Boeing and are operated by Spanair and American Airlines. AC

MD-80/-90 fleet analysis

Most MD-80s remain in service, and American & Delta account for more than 450. Aircraft with -217C & -219 engines are the most desirable.

There were 1,194 MD-80s and 117 MD-90s built. Of these, 1,042 MD-80s are still in active service and 105 MD-90s are operational. Production of MD-80s started in 1980 and continued until 1999, while the MD-90 was manufactured for just five years from 1995 until 2000.

The MD-80's initial customers was a concentrated group of airlines. These included American Airlines (261), Delta Airlines (121), TWA (57), Alaska Airlines (34), Texas Air (38), PSA (28), SAS (66), Alitalia (91), Swissair (25) and Iberia (24). These 10 carriers ordered 745 aircraft between them.

Other smaller fleets were also originally ordered by Aero Lloyd, Aviaco, Finnair, Japan Air System (JAS), Korean Air, Midway, TOA Domestic and USAir coming to another 111 aircraft between them. Eighteen airlines therefore ordered more than 850 MD-80s.

While the MD-80 fleet has started to be sold and dispersed to secondary users, many aircraft remain with their original operators. Furthermore, several original operators have acquired more MD-80s from other airlines. American has been especially active in increasing its MD-80 fleet and has acquired aircraft from Alaska Airlines, Swissair, Inex Adria Airways, Paramount Airlines and Boeing (ex-Chinese airlines aircraft). American also acquired TWA, and picked up 61 MD-80s in the process. American now has a fleet of 364 MD-80s, of which 337 are active, and the remainder are in storage.

Allegiant, Spirit Airlines, Lion Air and Jetsgo have all emerged as new MD-80 operators.

MD-81

The MD-81 was the second least popular of all MD-80 variants, mainly because of its low gross weight and short-range performance. Aircraft can be upgraded to MD-82 standard relatively inexpensively *(see MD-80 modification & upgrade programmes, page 14)*, however. There are still 54 of the original 80 MD-81s operational. Most MD-81s were ordered by Swissair (9), Austrian (4), TOA Domestic (11), JAS (12) and SAS (13).

Japan Airlines (JAL) Domestic now operates some of TOA Domestic's and JAS's aircraft. Ex-Swissair and ex-Austrian aircraft are now used by Midwest, Aero Colombia and Spirit Airlines. The majority of MD-81s still operating have a gross weight of 140,000lbs and 41 have the more desirable JT8D-217C engine rated at 20,000lbs thrust.

MD-82

The MD-82 is the most numerous variant of the MD-80 series, with 603 being manufactured between 1981 and 1997. Production was between line numbers 1,001 and 2,189. More than 500 are still operational.

American Airlines operates 242 of these active aircraft, all of which have a maximum take-off weight (MTOW) of 149,500lbs and standard fuel capacity of 5,840USG. Most of these are powered by the JT8D-217C (230) and another two by the -219. American will not phase out its MD-82s, and will put its fleet through a major refurbishment programme.

The other 263 MD-82s in operation are used by a variety of carriers. The largest fleets are Alitalia, SAS, China Northern, China Southern and China Eastern. Smaller original fleets are those of Aeromexico and Finnair, while fleets of used aircraft are operated by Spirit Airlines, Continental, Allegiant, Jetsgo, Comair, Bouraq, Lion Airlines, MNG and Eurofly. Most of these aircraft have gross weights between 140,000-149,500lbs and a standard fuel capacity of 5,840USG. One hundred and ten are powered by JT8D-217C. The majority are operated by Alitalia, but others are operated by Meridiana, Jetsgo, SAS, Far Eastern Air Transport, China Northern, Spirit, Midwest, Spanair and Aeromexico. Another 35 are equipped with the -219 and operated by Spirit, Nordic Airlink, SAS, Finnair, Aeromexico and Far Eastern Air Transport.

MD-83

The MD-83 is the second most numerous of MD-80 variants, with 277 being built between 1987 and 1999. The first line number was 1,370 and production ceased with line number 2,287. The MD-83 did not sell in larger numbers, despite having the highest MTOW, fuel tank and engine specification. By the time of its conception, however, alternative aircraft like the A320 were being offered.

Out the 277 manufactured, 255 are still operational. American Airlines has 95 of these, which with its 242 -82s, account for all its MD-80s still in operation. All except two of these MD-83s are equipped with the JT8D-219. American will keep its MD-83s operational.

The remaining 160 MD-83s in service are mainly used aircraft. All except three of these aircraft are equipped with the -219 engine. Only Alaska Airlines' fleet of 25 aircraft are the other major original fleet. Most other MD-83s are used aircraft operated by second-tier and third-tier users, including Austral, Helvetic, Spirit Airlines, Spanair, Allegiant, Nordic Airlink, Allegro Airlines, Lion Airlines and Meridiana.

MD-88

The MD-88 is almost the reserve of Delta Airlines. Out of 158 aircraft built between 1986 and 1993, 155 remain operational and 120 of these are utilised by Delta. These all have the standard specification of a gross weight of 149,500lbs and fuel capacity of 5,840USG.

The other 35 aircraft are operated by Onur Air, Iberia, Midwest, Aeromexico and Aerolineas Argentinas. The last three carriers operate 17 aircraft leased by GECAS. Iberia's fleet of 13 are powered by the JT8D-217C, while the other 142 aircraft are equipped with the -219.

MD-87

Only 76 MD-87s were built, from line number 1,326 in 1986 to line number 1,985 in 1992. Seventy one of these aircraft are still operational. All are equipped with the JT8D-217C or -219.

The MD-87's largest users are Iberia (24), SAS (16), JAS/JAL Domestic (8) and Austrian Airlines (4). The remaining aircraft are used examples, operated mainly by Aeromexico, and Allegiant Air.

MD-90

The MD-90 fleet is concentrated in a small number of fleets operated mainly by JAL Domestic (16), Delta Airlines (16), SAS (8), Saudia (29), China Northern (13), China Eastern (9) and Uni Airways (11). The majority of aircraft are with their original operators, although a few have changed hands. SAS's aircraft are available on the market, and Delta will phase out its fleet over the next few years. AC

MD-80 modification & upgrade programmes

The MD-80 has no prospects for conversion to freighter, but does have a durable airframe. There are several performance enhancing modifications.

The modification and upgrade programmes for aircraft generally fall into four categories: gross weight and fuel capacity upgrades; avionic modifications and installations; passenger-to-freighter conversions; and noise and fuel burn reduction programmes.

Despite the durability of its airframe there are no passenger-to-freighter modifications for the MD-80, because its fuselage cross-section is narrower than that of all the other narrowbody freighters: the 727, 737 and DC-8. There are, however, other types of modification available for the MD-80.

Gross weight & fuel capacity

There are several variants of the MD-80 series, and several gross weight and fuel capacity specifications for each variant. The three main variants are the MD-81, -82 and -83.

The MD-83 has the highest gross weight of 160,000lbs. There are five different fuel capacity versions for this gross weight, varying between 5,840US Gallons (USG) and 7,780USG *(see MD-80/-90 specifications, page 10)*.

The MD-82 has two gross weight options: 147,000lbs and 149,500lbs. Both have a fuel tank capacity of 5,840USG. The MD-81 has the same fuel tank capacity, and lower gross weight of 140,000lbs.

It is possible to increase gross weight or fuel tank capacity, or both. The MD-81's specification can thus be upgraded to the -82's or -83's. Upgrading to the MD-82 would increase range by up to 600nm, while an upgrade to the -83 would increase range by up to 1,000nm.

Upgrading the MD-81 to the -82 only requires an increase in maximum take-off weight (MTOW). This involves structural strengthening, which is possible with the purchase of a kit from Boeing, which has a list price of $570,000. The upgrade incurs the additional cost of man-hours (MH) used during installation.

Upgrading the MD-81 to the MD-83 involves increasing the MTOW and adding auxiliary fuel tanks that add between 565USG and 1,940USG. Increasing just the MTOW to 160,000lbs would improve the aircraft's range by 700nm, while installation of auxiliary fuel tanks of up to 2,300USG capacity would add a further 350nm of range.

Increasing the MTOW requires strengthening the aircraft structure, and the kit from Boeing has a list price of $900,000, plus MH for installation.

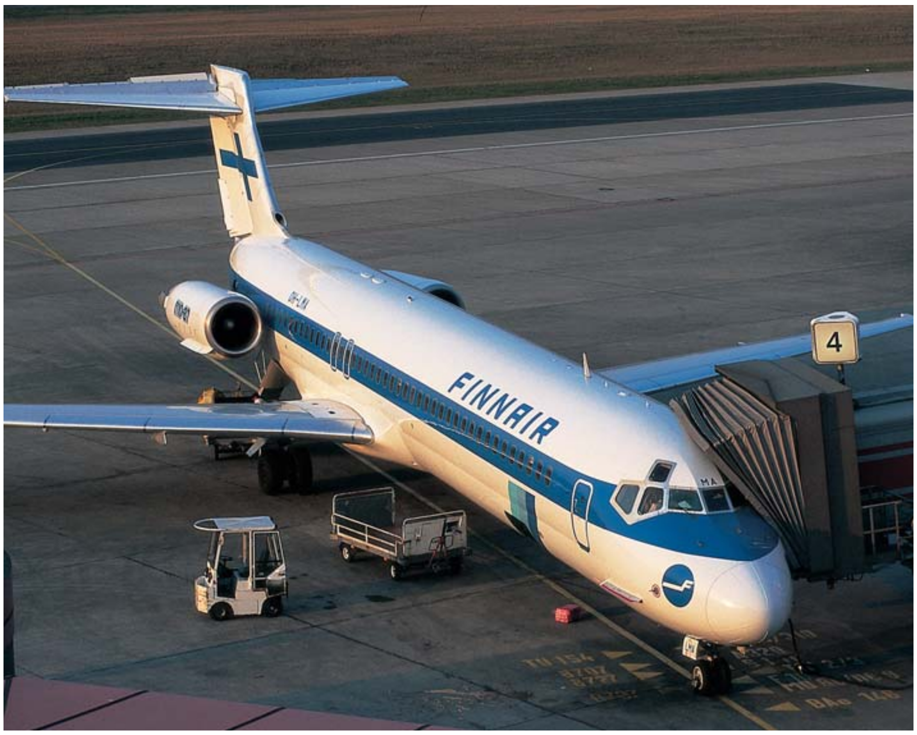
The MD-82 can be upgraded to the MD-83 by an increase in MTOW from 149,500lbs to 160,000lbs and installing auxiliary fuel tanks with 565-1,940 USG.

The MTOW upgrade kit has a list price of $570,000.

Avionic upgrades & installations

Various avionic modifications have become mandatory for all aircraft over the past few years in different operational areas, including: the use and installation of 8.33 KHz VHF channel spacing on VHF radios in Europe; traffic collision avoidance system (TCAS); enhanced ground proximity warning system (EGPWS); reduced vertical separation minima (RVSM) in Europe and the Atlantic Ocean Area; Area Navigation Requirements (BRNAV/PRNAV) in Europe; air traffic control (ATC); mode S transponder additional parameters in Europe and hardened flightdeck doors. There has also been an airworthiness directive (AD) for the installation of insulation blankets in the fuselage walls.

In addition to these, it is possible to retrofit MD-81s, -82s and -83s with electronic flight instrument system (EFIS) that is standard on the MD-88 to gain better situational awareness for navigation. "The Honeywell flightdeck used on the MD-88 is still available," says Mikko Koskentalo, assistant vice president component department at Finnair Technical Services. "We installed these to comply with European Navigation requirements along with a Flight Management System and dual GPS and Scanning DMEs as positional sensors. Overall it complies with the European requirements for RVSM and navigational accuracy until at least 2008.



There are several avionic modifications for the MD-80 and a hardened flightdeck door that are mandatory in Europe and the US, which cost about $350,000. As an alternative to these avi0nic modifications, airlines can install an EFIS flightdeck at a total cost of about $1 million.

SAS has a fleet of 56 MD-80s, and is considering modifying its aircraft with Jet Engineering's Stage 4 hushkit so that it can operate the aircraft for another 10 years. This will reduce noise, cut fuel burn by about 2% and improve engine on-wing life. SAS may also consider installing winglets.

The cost of installing this type of flightdeck is close to $1 million per aircraft if all the systems are added. It uses more than 1,500MH."

Koskentalo explains the costs of additional avionic upgrades. Each of these are mandatory in various parts of the world, at least in European operational airspace. Installation of RVSM is mainly an accuracy requirement for altitude measurement and flying capability. The typical cost is $30,000 per aircraft and requires about 30MH. The installation of 8.33 KHz radio channel spacing is a VHF Comm radio and control panel modification and minor wiring changes, with a price of $100,000 and about 50MH for installation. The kit for EGPWS/TAWS costs about $80,000 and uses about 100MH. The kit for ATC mode S transponder and TCAS installation costs about $250,000 and requires 800MH for installation. These last two modifications are already mandatory for aircraft operating in US and European airspace, however.

"A hardened flightdeck door has a kit price of $100,000 and uses about 100MH for installation. These are mandatory at least for aircraft operating in European and US airspace," says Koskentalo. "The cost of installing insulation blankets varies with the number of blankets to be replaced. This is covered by AD 2000-11-01, and must be complied with by June 2005. It is mandatory for aircraft operating in all parts of the world."

Noise & fuel burn reduction

The MD-80 is compliant with Stage 3/Chapter 3 noise regulations, and so hushkit and noise reduction modifications have not been needed so far. There is now, however, a Stage 4 noise compliant programme that has already been developed for the MD-80. Although it is not mandatory to make older generation aircraft Stage 4 compliant, it is possible that there will be legislation requiring aircraft to be modified. Jet Engineering and Goodrich Aerostructures are co-operatively marketing a noise reduction kit for the MD-80. This has been developed by Jet Engineering, and the system received its supplemental type certificate (STC) from the Federal Aviation Administration in June 2004. The kit has also completed its European approval and expects to receive the European equivalent of the STC by the end of April 2005.

The kit makes the MD-80 Stage 4 compliant by a margin of up to 13 decibels. Margins vary with the different MD-80 variants.

The system works by remixing the jet exhaust and spreading it over a larger area in the outlet nozzle of the engine by use of a lobed exhaust mixer.

The system reduces noise, but also reduces block fuel burn by 1.5-2.0%. Jack Anderson, president at Jet Engineering explains this is because the exhaust mixer improves the exhaust flow coefficient. The system also reduces exhaust gas temperature (EGT) by about 10 degrees centigrade, which enhances on-wing life and shop visit removal intervals.

Anderson says the system has already been proven in a Pratt & Whitney-approved test cell in San Diego over the course of a year-long study, and Pratt & Whitney has also approved the system for use on the JT8D-200.

The list price of the kit is $750,000, including installation. Installation can be accomplished with a thrust reverser change during an overnight check, with the kit already installed on a modified thrust reverser.

Payback for the system is achieved mainly through fuel burn savings. An MD-80 will typically operate at a utilisation of about 2,000 flight cycles (FC) per year, with an average FC time of about 1.3 flight hours and fuel burn per trip in the region of 1,250USG. A fuel burn reduction of about 2% will save about 50,000USG per year, equal to about $55,000 per year.

Anderson says that studies show that the reduction in EGT of about 10 degrees will save operators $11-16 per EFC. This will be equal to up to $60,000 per year at typical rates of utilisation. The savings from reduced fuel burn and EGT could therefore reach about $120,000 per annum. Anderson points out, however, that European operators would also benefit from reduced fees for noise penalties of as much as $160,000 per year. With these included, the kit will achieve a full payback in just three years.

SAS has confirmed that it is considering modifying its MD-80 fleet with both the Jet Engineering Stage 4 kit, and also with winglets that are being developed by Aviation Partners Boeing. The airline has 56 MD-80s and has said that these modifications will allow it to operate the aircraft for another 10-15 years, adding that it would not receive any economic benefit from replacing them with current generation narrowbodies.

The winglets would provide an additional fuel burn saving of 2.5-3.0%. This would save about 75,000USG and $82,000 per year. The winglets would also achieve a small reduction in aircraft noise. This saving compares to a list price of $600,000 for the winglets, and so allowing a payback over a seven year period. So far SAS is the only airline to show interest, and APB would need a launch customer before progressing with certification.

The modifications to the MD-80 would give it a wide margin over Stage 4 compliance and allow SAS to operate the aircraft until Airbus and Boeing have developed a new generation of narrowbody aircraft types. AC

MD-80 maintenance analysis

The MD-80's durability is reflected in its low total maintenance costs.

There are several elements to the MD-80/-90's maintenance requirements: line maintenance; hangar checks; heavy components; line replaceable components; engine maintenance; and the provision of technical support for the aircraft in operation.

This analysis considers these elements, and provides a maintenance cost budget for the MD-80 and -90 based on an annual utilisation of 2,500 flight hours (FH) and 1,900 flight cycles (FC) per year. This is for an average FC time of 1.33FH. It is also assumed the aircraft is operational for 350 days per year, and so achieves an average of 7.1FH and 5.4FC per day of operation.

Maintenance programme

The MD-80 was certified as a variant of the DC-9. The MD-80 therefore has a maintenance programme based on maintenance steering group 2 (MSG2) principles. The MD-90 was, however, conceived on MSG3 principles, where maintenance tasks can be grouped according to the convenience of each operator.

It is technically possible for MD-80s to be bridged from a MSG2 to a MSG3 maintenance programme. Most operators, however, find this uneconomic given the probability that they will not continue to operate the MD-80 for much longer. "Our MD-80 maintenance programme could be described as being between MSG2 and MSG3," explains Paul Burakoff, maintenance engineer for heavy aircraft maintenance at Finnair Technical Services. "Our programme is based on the original MSG2 programme and has extended intervals. This involves the normal pre-flight check at the start of each day's operation, a transit check before all other flights during the day, daily checks every 24-48 hours and A checks every 600 flight hours (FH) in the line maintenance programme.

"Our base maintenance programme is the standard pattern of three C checks, followed by an intermediate heavy (I) check, followed by another three C checks and then completed with a full heavy (D) check," continues Burakoff. This is the MSG2 programme followed by most MD-80 operators. The C check interval is 4,800FH or 18 months, whichever is first. The I check interval is 16,000FH or 66 months, and the D check interval is 30,000FH or 120 months. All checks are zeroed when the D check is performed. Our aircraft have an annual utilisation of about 2,300FH per year, meaning they accumulate about 3,500FH in the 18 month C check interval."

While many MD-80 operators have remained with a MSG2 programme, a few airlines have elected to adopt the MSG3 programme for their fleets. SAS Technical Services (STS), a maintenance subsidiary of Scandinavian Airlines System (SAS), has implemented the MSG3 programme on SAS's fleet of 56 MD-80s. "The MD-80's MSG2 programme has equalised A and C checks which have FH limits, and I and D checks that are calendar limited by corrosion prevention and control programme (CPCP) requirements," explains Harrald Petersen, manager of engineering at STS. "As the MD-80 ages it requires more structural maintenance. Some items have high initial thresholds and so start being added to the maintenance programme. There is also the issue of the CPCP, ageing aircraft programme and structural inspection document. A MSG3 maintenance programme incorporates all of these into a common maintenance schedule. Moreover, future owners and operators of MD-80s are likely to prefer aircraft with a MSG3 programme. One reason is that less bridging maintenance is required when changing an aircraft between operators. We have therefore decided to develop a MSG3 maintenance schedule for our MD-80s and are in the process of bridging the aircraft from the MSG2 maintenance system.

"A MSG3 system basically allows an operator to package individual tasks and inspections into the checks that best suits its operation," continues Petersen. "Tasks have to be organised to achieve a compromise between small and frequent checks and large, infrequent checks. STS has created its own MSG3 job cards from Boeing's task cards, and hard-time items have been removed from the programme. The environmental deterioration (ED) tasks in the MSG3 maintenance programme are basically the CPCP tasks from the MSG2 programme. Overall, this has resulted in a new maintenance schedule with a C check interval of 21 months and 4,800FH. There are 1C items and multiples of these: that is 2C, 3C, 4C, 5C, 6C and 8C tasks, which are grouped with 60-month, 72-month and 120-month ED tasks and arranged to form block checks. The C2 check, for example, consists of the 1C and 2C items.

"Every third C check is like a MSG2 I check, and the 1C items are combined with the 3C, 4C and 5C tasks. The 60-month and 72-month ED inspections are also added," continues Petersen. "This is followed by another two C checks, the C4 and C5 checks, and then followed by the C6 check, which is the heaviest check in the cycle. This means there are structural inspections every third check. The basic interval is 21 months. We estimate that by converting to a MSG3 programme there will be a 30-40% reduction in routine man-hours (MH) across the C check cycle, mainly because duplication of tasks in the C3 and C6 checks will be avoided. This will also result in a reduction in non-routine MH, although it is too early to estimate what the magnitude of the saving will be."

"There is also a stream of A checks, which operates independently of the C checks," says Petersen. "These will have an interval of 600FH."

MD-90 programme

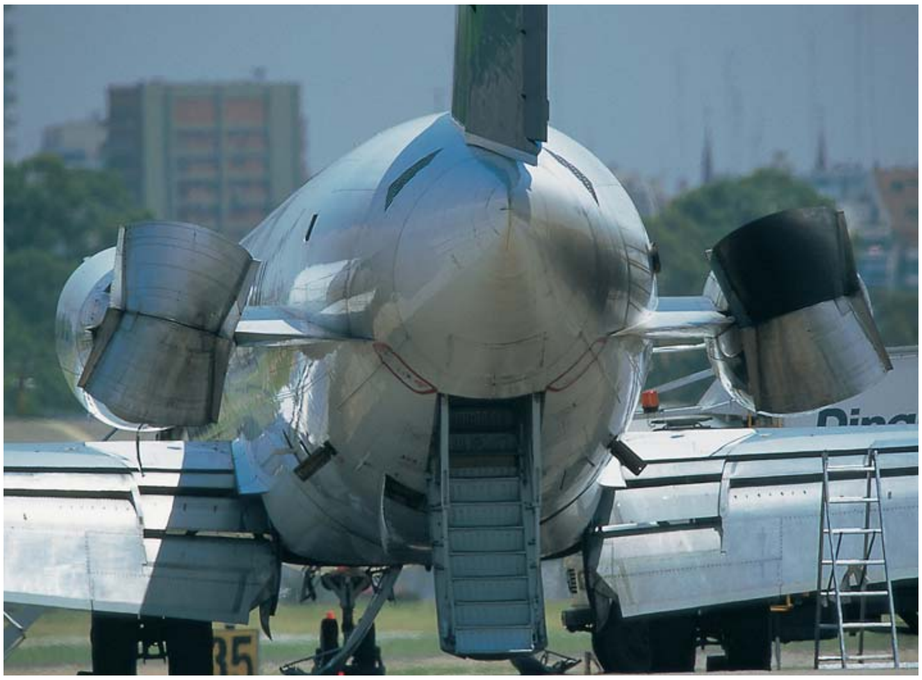
The MD-90 was certified with a MSG3 maintenance programme. STS has arranged tasks into checks for SAS's fleet of MD-90s that are not too dissimilar from its MD-80's maintenance schedule.

There are A checks with an interval of 550FH and P checks, or C checks, with a 4,000FH and flight cycle (FC) interval. There is also a separate group of structural tasks. These have initial intervals of 60, 90 and 120 months. Most MD-90s were delivered between 1995 and 1999, and so only the oldest aircraft will have had their tasks with an initial interval of 120 months completed. The same structural tasks then have repeat intervals of 30, 45 and 120 months.

SAS groups the structural tasks with the C checks, depending on when each one is performed. The aircraft accumulate about 2,500FH per year, and so have a C check every 18-20 months.

Line maintenance

Like all other aircraft types, the MD-80 has a basic line maintenance schedule of pre-flight checks prior to the first flight of the day, a transit check before all other flights in the day and a daily check performed overnight every 24-48 hours. On this basis, and the assumed level of utilisation, an aircraft will require about



The MD-80 is durable, and enjoys stable and low maintenance costs. This is attributable to its low base maintenance-related costs and engine reserves. This makes the MD-80's direct operating costs predictable, and so a strong aircraft candidate for start-up airlines.

350 pre-flight checks, 1,550 transit checks and 300-350 daily checks per year.

Estimation of man-hour (MH) and material cost inputs are approximate. Pre-flight and transit checks each use about one MH, and can be performed by flightcrew. A budget of $15 for materials should be allowed. Daily checks are larger, and use about two MH and $40 for materials. Some airlines, such as SAS, have weekly checks and use up to 20MH and $200 of materials. The largest line checks are the A checks. These vary in size, and STS has divided them into two halves, each with an interval of 275FH. Interval utilisation is relatively low for line checks, and this analysis assumes an actual interval of 200FH. The MH used varies between 65 and 100, and an average of 85 is taken. Material cost can also vary widely, and a conservative average of $700 is used.

Over one year's operation, line maintenance will use about 4,600MH and $60,000 in materials. At an average assumed labour rate of $70 per MH, the labour cost for this would be $322,000. This takes the total labour and material cost for line maintenance to about $383,000. When amortised over the annual utilisation of 2,500FH, it is equal to a rate of $153 per FH *(see table, page 20)*.

Airframe checks

The maintenance budget analysis assumes a MSG2 maintenance schedule for the MD-80. Similar to Finnair's maintenance programme, this is a C check with an interval of 4,800FH and 18 months, and a sequence of base checks terminating with a D check with an interval of 30,000FH and 120 months. This D check coincides with the eighth C check in the cycle.

At an annual utilisation of 2,500FH, an aircraft will accumulate about 3,750FH in the 18-month interval. The actual C check interval achieved will be about 15 months in the case of most operators. This will be equal to about 3,100FH. The eighth C/D check will thus be performed at about a 120-month interval, its actual maintenance programme interval, and 25,000FH.

"The non-routine ratio for base checks has changed little with age. We have performed second D checks on 20-year old aircraft," explains Burakoff. "C checks are similar in size. We use an average of about 1,500MH for C checks, including our own originated tasks for cleaning and cabin refurbishment. This is a total that includes about 1,000MH for routine tasks, another 400MH for non-routine corrections, and about another 200MH for cabin work. This would take the total for all items to 1,700-1,800MH. Modifications would add additional MH. This is actually less MH than we use for a C check on an A320, which has a lot of system inspection requirements. C checks also use about $11,000 for materials for routine work, and a further $17,000-30,000 for materials for defects."

Rune Marthinsen, head of marketing, sales and purchasing at STS heavy maintenance makes a similar estimate of up to 1,500MH for C checks for MD-80s kept on a MSG2 programme.

A base maintenance labour rate of $50 per MH takes total cost for the check to $120,000-130,000.

I checks are heavier, and are the smaller of the two structural checks. "The I checks have about 200 different items. The routine inspections use about 12,000MH to complete, with about 45% of this being used for non-routine and cabin work. About another 5,000MH are required for large modifications, such as the installation of insulation blankets, but these are one-off items and these will not affect the subsequent heavy checks. ADs, SBs and interior work also have to be considered, and so the total MH consumption for a mature aircraft will go up to 16,000-18,000. Materials for routine inspections and defects will be about $150,000, while the additional cost for major modifications and interior work and cabin refurbishment will add up to another $330,000. Material cost can reach about $450,000-500,000."

This compares to Marthinsen's estimate of 15,000-20,000MH and $600,000 for materials for this check.

A labour use of 18,000MH charged at a rate of $50 per MH and a further $550,000 for materials will take the total for the check to about $1.45 million.

Routine and non-routine D check tasks consume about 26,000MH. "This is split into about 15,000MH for the routine items and 11,000MH for the non-routine tasks. This also includes about 5,000MH for interior work for cleaning and refurbishment, as well as labour for CPCP and ageing aircraft tasks," says Burakoff. "Another 2,000MH could be used for stripping and repainting, while a further 2,000MH can be used for modifications, so that the total for the check can approach 30,000MH. The check will also use about $800,000 in materials for routine inspections, defects, modifications, cabin refurbishment and painting. The downtime for the check is up to five weeks." The standard labour rate would take the total cost of the check to about $2.3 million.

The total for the six C checks, I check and D check in the full base check cycle will be an expenditure of $4.5 million, including about 58,000MH. This compares to 45,000-50,000MH used for an A320 in its first base check cycle with a similar interval of 25,000FH.

The MD-80's total costs amortised over an interval of about 25,000FH, and 120 months, results in a reserve of about $182 per FH *(see table, page 20)*.

All MD-90s are young and no aircraft have yet completed a heavy check cycle. STS has a system of C or 'P' checks every 4,000FH/FC, and only has experience of the first four or five 'P' checks in the heavy maintenance cycle. Marthinsen estimates that MH inputs for the lighter

'P' checks are in the region of 1,200-1,500MH, while the heavier P4 check uses 10,500-12,000MH. Cost of materials for the lighter check would be $10,000-18,000, and $400,000-450,000 for the heavier P4 check. Using an assumed labour rate of $50 per MH would take total cost for these first four checks to about $1.25 million.

This would be over an interval of about 14,000FH, considering typical interval utilisation rates. The cost would be equal to a reserve of $90 per FH. This compares favourable to the MD-80's base maintenance reserve under a MSG2 programme, and indicates the savings that can be accrued from operating an an with a MSG3 philosophy.

Heavy components

Heavy components, which are maintained on a separate schedule from the airframe checks and on an on-condition basis, include the auxiliary power unit (APU), wheels and brakes, landing gear and thrust reverser units. The maintenance cost of these components is related to a FC interval. Maintenance cost should therefore be examined on a per FC basis, and then converted to a rate per FH according to the average FC time.

The MD-80 is powered by the GTCP85-98 APU. The cost per FC is determined by the average shop visit cost, the APU hours interval between shop visits and the ratio of APU hours to FCs.

The number of APU hours per FC depends on each airline's operation. The APU is typically used between landing and arrival at the terminal gate, and may either be kept running while the aircraft is on the ground or stopped and re-started prior to engine start and pushback. On the basis of the assumed daily utilisation, the aircraft will spend five to six hours on the ground between flights with an average of just over an hour between each flight. Most airlines will switch off the APU and use ground power for some of this downtime. In this case the APU may be switched on twice for a total time of about 30 minutes per aircraft cycle. The APU time per FC would exceed one hour if it was kept on for the entire downtime between flights. In the former case, the average APU utilisation would be 950 APU hours per year. This is a ratio of about 30 APU minutes per FC. The average shop visit interval for the GTCP 85-98 is about 3,000-4,000APU hours, and average shop visit cost in the region of $125,000. This is thus equal to a rate of $35-40 per APU hour, and $17 per FC *(see table, page 20)*.

Thrust reversers for the JT8D-200 are an old generation type. Although maintained on-condition, operators have established average or 'soft' removal intervals. Since they are used at most landings, removal intervals are related to number of FCs. Average removal intervals are partially related to weight of the aircraft, with the MD-83s and -88s having harder braking at landing and so shorter removal intervals. Typical intervals for MD-80 thrust reversers are 7,000-8,000FC.

The average shop visit cost for each reverser unit is in the region of $170,000, similar to the reverser on the JT8D Standard series. The cost for a shipset of two is thus $340,000, and so the reserve for thrust reverser repair is $45 per FC *(see table, page 20)*.

The total cost for wheels and brakes is broken into several elements. The first of these is tyre remoulding and replacement. Intervals are on-condition, and operating climate affects removal intervals, as does aircraft weight and pilots' treatment at landing. Like thrust reversers, the heavier MD-83s and -88s will have shorter tyre remould intervals than the -81 and -82.

In Finnair's experience, main wheel tyres have an average removal interval of 500FC between retreads and are remoulded twice on average before replacement at the third removal, thus not exceeding the life limit of 1,800FC. "A main tyre re-tread costs about $400," says Koskentalo. "Nose tyres are remoulded about every 350FC at an average cost of $170. These are remoulded about four times before being replaced after a total life of 1,750FC."

New main wheel tyres cost about $1,400 and new nose wheel tyres about $250. Overall, the total cost for tyre remoulding and replacement is about $9-10 per FC *(see table, page 20)*.

Wheel inspections are made at the same time as tyre remoulds. Nose wheels are thus put through the shop about every 350FC, and main wheels about every 500FC. Nose wheel inspection shop visits cost about $600, and main wheel inspections about $650. Main wheel brake units are steel and have an interval about every 1,000FC; in the case of the MD-80 about every second wheel removal. Brake inspections have a cost of about $10,000. Overall, the wheel inspections and brake repairs have a total cost of about $48 per FC *(see table, page 20)*.

Landing gear overhaul intervals are the same for all other types; eight to 10 years. Koskentalo says shop visit exchange fees are in the region of $350,000, and an interval of nine years is equal to about 17,000FC. The cost for landing gear overhaul and exchange is thus about $21 per FC *(see table, page 20)*.

The total for all four categories of heavy components is thus about $140 per FC. At an average FC time of 1.33FH, this is equal to $105 per FH *(see table, page 20)*.

Line replaceable components

Many major MD-80 operators own their own inventories of line replaceable units (LRUs) and have their own in-house repair facilities and shops. Identifying the direct cost of this and separating it from overheads is difficult or impossible.

One way of analysing probable costs of having access to enough LRUs to maintain a reliable operation and paying for their associated repair and management is to examine the costs a small operator has to bear by acquiring this service from a third party supplier. An airline with a fleet of 10-15 aircraft can have access to sufficient LRUs by leasing a homebase stock and pay a power-by-the-hour (PBH) rate for access to a pool of inventory of the remaining parts. These would be items that have lower failure rates or do not have such an impact on the aircraft's operation when they fail. The airline would then pay a third fee, as a PBH rate, to the supplier for the management and repair of the components.

Koskentalo quotes a PBH rate of about $27 per FH for the lease of homebase stock. The access fee for the pool stock of remaining parts would be in the region of $34 per FH. The PBH fee for the repair and management of all parts would be the largest element: Koskentalo quotes in the region of about $125 per FH. Overall, the total for all three elements would be about $186 per FH *(see table, page 20)*.

Engine maintenance

MD-80 operators manage their engines in different ways. Some take an on-condition approach to engine maintenance, while others try to manage removal intervals and shop visit workscopes to match LLP life expiry and achieve the lowest possible cost per engine flight cycle (EFC) and engine flight hour (EFH).

The average interval between scheduled removals is 4,000-6,000EFC, equal to about 6,000-8,000EFH for an average EFC time of 1.33EFH. Some operators, however, manage to achieve

DIRECT MAINTENANCE COSTS FOR MD-80/-90

Maintenance Item	Cycle cost $	Cycle interval	Cost per FC-$	Cost per FH-$
Line checks	$383,000	2,500FH		153
Hangar checks	$4,500,000	25,000FH		182
Heavy components:				
Landing gear	$350,000	17,000FC	21	
Tyre remould & replacement	$16,000	1,750FC	9	
Wheel inspections	$4,000	500FC	8	
Brake inspections	$40,000	1,000FC	40	
Thrust reverser overhauls	$340,000	7,500FC	45	
APU	$125,000	7,500FC	17	
Total heavy components			140	105
LRU component support				186
Engine maintenance				316
Spare engine coverage				40
Total				**990**

Based on an annual utilisation of 2,500FH and 1,900FC.

scheduled removals every 8,000-9,000EFH.

EGT margins are 15-25 degrees centigrade after an overhaul, and these are low compared to modern engine types. Erosion rates are 3-4 degrees per 1,000, but allow long removal intervals and do not affect rates of removal.

Most JT8D-200s conform to an alternating pattern of hot section inspection and overhaul shop visits. Some operators try to match this pattern with LLP replacement. LLP lives that are currently saleable have uniform lives of 20,000EFC, and heavier shop visits are more appropriate for LLP replacement, which is targeted for every second overhaul shop visit. In this pattern of four shop visits, however, there is also usually a smaller unscheduled shop visit making a total of five shop visits every LLP replacement cycle.

Taking an average scheduled removal interval of 4,500EFC, the cycle would be completed about every 18,000EFC. This compares to LLP lives of 20,000EFC, which have a list price of $990,000. LLP amortisation would therefore be about $55 per EFC.

The inputs for a lighter, hot section inspection are 1,800-2,200MH, about $200,000 for materials and parts, and $100,000 for sub-contract repairs. A standard labour rate of $70 per MH would take total shop visit cost to about $450,000.

Inputs for an overhaul are 3,000-4,500MH, $350,000 for materials and parts and $150,000-250,000 for sub-contract repairs. This would take the total cost for a shop visit to $750,000-900,000.

The average cost for a smaller, unscheduled shop visit would be in the region of $250,000. The total cost for five shop visits over the LLP replacement cycle would thus be about $2.8 million. Amortised over the interval of about 18,000EFC the cost would be equal to $155 per EFC. Added to LLP replacement it would take total reserve for all maintenance to $210 per EFC, equal to $158 per EFH. Maintenance reserve for both engines would be $316 per FH *(see table, this page)*.

Maintenance reserves for the V.2500-D5 powering the MD-90 will be higher. Although the engine has long removals between shop visits, it has higher cost of materials. Reserves therefore tend to be equal or higher to average rates per EFH for the JT8D-200.

Operators also have to consider the costs of spare engine provisioning. Removal intervals of about 7,000EFH and rate of aircraft utilisation means each engine has a scheduled removal about once every three years. An average shop turn time of three months means one spare engine could support about 10 installed units, equal to a fleet of five aircraft. The market value of JT8D-200s varies depending on variant, but Tom MacAleavey, senior vice president of sales and marketing estimates at Willis Lease Finance Corporation the value of -217s or -219s in a good maintenance status to be $1.5-2.0 million.

Airlines can consider leasing spare engines as an alternative to ownership. Some engines will have to be leased as additional cover to owned spare engines. Willis Lease Finance Corporation is the world's largest lessor of JT8D-200s, with a portfolio of 26. MacAleavey says lease rates for JT8D-217s and -219s are about $1,000 per day at current market rates, or about $30,000 per month. A fleet of five MD-80s could be supported year-round with a leased engine, incurring a cost of about $360,000, plus additional cost for leasing other engines on for short periods. Maintenance reserves also have to be considered for the leased engine, and are in the region of $140 per EFH plus $51 per EFC. Considering that the annual cost for single engine may be in the region of $500,000, and so $100,000 per aircraft, an additional rate of $40 per FH could be added to maintenance costs.

Lease rates for V.2500-D5 engines are at about $2,000 per day, or $60,000 per month. Maintenance reserves are high, however, at $266 per EFH plus $97 per EFC. MacAleavey puts market values at about $5.5 million. Removal intervals are longer, meaning a spare unit can support a larger fleet of 12-14 aircraft.

Maintenance cost summary

The total for all maintenance cost elements for the MD-80 is $990 per FH. Aircraft kept under a MSG3 programme may have marginally lower costs because of a reduction in base maintenance-related costs.

While the MD-90 may have lower base maintenance-related costs, it could be expected to have similar line and component maintenance related costs. The MD-90's V.2500 engines, however, will have higher reserves than the JT8D-200, and this will more than outweigh the benefits of lower base maintenance costs. The MD-90 has higher overall maintenance costs per FH than the MD-80.

Technical support

The MD-80 is an ideal aircraft for start-up carriers. Initial operations require a lot of training and development of in-house expertise, and so airlines may seek technical support from a third party provider to assist them. The different types of support an airline could consider include maintenance operations control, management of LRU inventory and logistics, management of aircraft maintenance and maintenance records, and engine condition monitoring and maintenance management. Finnair can provide this type of support to customers and Koskentalo quotes a rate of $20-55 per FH, depending on fleet size and several operational parameters. The higher rate includes having staff on site to assist with the operation. AC