The MD-80 will arrive on the secondary market in a few years. Successful disposal will be influenced by dependable maintenance costs. Airframe and component maintenance requirements and costs are examined in detail.

MD-80 airframe and component maintenance cost guide

The MD-80 still remains in service with first-tier operators but will soon face displacement from the largest fleets. With arrival on the secondary market just a few years away, prospective secondary operators need to be accustomed to the MD-80's maintenance requirements and characteristics.

The MD-80 has much of the same technology and construction as the DC-9 and yet the MD-80 does not consume an excessive amount of maintenance compared with new technology aircraft. The aircraft's maintenance programme was recently changed from MSG-2 to MSG-3 and this will deliver estimated man-hour savings of up to 20%.

Maintenance programme

The MD-80's maintenance programme was originally based on maintenance steering group (MSG) 2 principles. This was based on the date the aircraft entered service.

The original maintenance planning document (MPD) and maintenance programme was simple and had relatively few airframe checks. Many operators therefore stuck to the programme but managed to extend check intervals.

Line maintenance was based on a pre-flight check, a daily check and a weekly check. Operator's intervals for these checks have been extended over time as experience of the aircraft has accumulated over 20 years. While some operators do a service check every 24 hours, some have extended the interval to as much as 72 hours.

The airframe check programme was based on an A-check, C-check, and two structural checks performed at 15,000 and 30,000 flight cycles. The 15,000 flight cycle check is known by some operators as the IV or intermediate check and the 30,000 as the D-check.

The MPD A-check interval is 450 flight hours and the C-check interval 3,500 flight hours or 15 months, whichever comes first. Most MD-80 operators have a flight hour to flight cycle ratio of about one hour and 30 minutes and achieve 2,500 flight hours and 1,670 flight cycles per year. This annual utilisation implies that most carriers would only get about 3,100 flight hours between C-checks.

McDonnell Douglas (MDC) has succeeded in selling almost 1,200 MD-80s and the aircraft have been in service since 1978. Analysis in more recent years of the ageing aircraft's programme led to MDC adopting MSG-3 philosophy for the aircraft's maintenance programme.

MSG-2 to MSG-3

"There are now two Maintenance Review Board (MRB) documents approved for the MD-80," explains Mike Paone, manager of maintenance programmes and plans at Boeing Long Beach. "The original was based on MSG-2, but when we considered the ageing aircraft issues we realised the best way to approach it was to completely re-analyse the maintenance programme and base it on MSG-3 philosophy. This was done about three years ago, and the MD-80 got MSG-3 approval in March 1996."

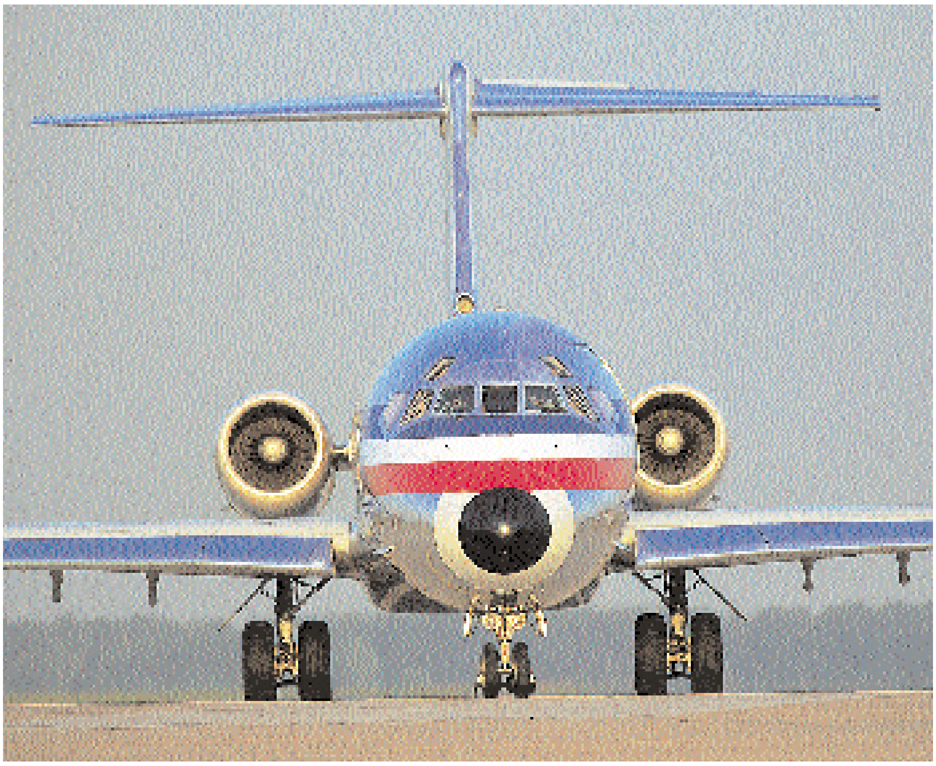
The MSG-3 maintenance programme changed the check intervals. The C-check interval was extended to 3,600 flight hours.

The aircraft's corrosion prevention and control programme (CPCP) was incorporated into the 15,000 and 30,000 flight cycle structural checks. They are therefore composed of two groups of inspections; the original structural inspections and the CPCP inspections. The structural inspections are termed general visual inspections (GVI) and the CPCP inspections called Detailed Inspections (DI). Each GVI and DI has its own initial and repeat intervals. The initial and repeat intervals of each GVI are the same and are either 15,000 cycles or 30,000 cycles, hence the 15,000 and 30,000 cycle structural checks.

The DIs have initial and repeat intervals which are fixed on a calendar basis. The initial intervals are 72 months for exterior items and 60 months for interior items. The repeat intervals are 36, 48, 60, 72 or 96 months.

Therefore, an inspection item can have a GVI with initial and repeat intervals of 15,000 cycles and DI initial and repeat intervals of 72 and 36 months. The depth of work required by a DI means the GVI is automatically done at the same time. Considering that no operator will be able to perform 15,000 cycles in a 36-month period, a DI will be performed before a GVI. Performing DIs therefore cancels any requirement to do GVIs.

This means that under a MSG-3 programme, the structural inspections can be broken down into items with the



The MD-80's maintenance programme has been changed from MSG-2 to MSG-3 philosophy in recent years. Man-hour savings of 20% are predicted. This could reduce airframe and component flight hour costs by $100.

different calendar limits of 36, 48, 60, 72 and 96 months. These can then be scheduled to coincide with the 15 month C-checks. This, however, either requires an operator to perform some of the checks early, or apply for an extension. For example, the 36 month items can be performed 6 months early or the operator can attempt to get a nine month interval extension.

Some airlines have adopted the MSG-3 programme for the A and C-check element of their maintenance schedules. One example is Swissair.

"Operators are now split about 50:50 between MSG-2 and MSG-3 maintenance programmes," says Paone. "Those which have adopted a MSG-3 schedule anticipate man-hour savings of up to 30%. MDC predicted that an average saving of 15% to 20% was probable. This is for an operator running its CPCP with the escalated check intervals.

"An airline still using an existing MSG-2 programme can take parts of the MSG-3 programme. This requires an analysis to make sure all related tasks are included," explains Paone.

"We are encouraging airlines to adopt a MSG-3 programme, since we have found that many tasks are not necessary," says Paone. "MSG-3 has also identified tasks not included in MSG-2."

The structural inspection document (SSID) is not yet mandated on the MD-80 fleet. It is now being developed and should be implemented in about two years. "The MD-80 has a design objective of 75,000 cycles and the fleet leader has not yet met this. The SSID goes beyond this design goal limit," explains Paone.

CPCP & Ageing aircraft

There are two methods of complying with the aircraft's CPCP and these are both linked with the ageing aircraft programme. The first is the original CPCP which is mandated by Airworthiness Directive (AD) 92-22-08. Any aircraft beyond implementation age for each task must perform the task within one repeat interval. Airlines must also do the inspection on at least one aircraft per year. The second method of compliance is incorporation of the MSG-3 structures programme.

Implementation of the aircraft's CPCP began in 1994. There are several tasks and each has its own implementation threshold and subsequent repeat inspection frequency. Implementation and repeat inspection intervals are all in calendar years. If an aircraft had passed the implementation age for a particular inspection in 1994, that inspection had to be performed within one repeat interval.

The implementation age of CPCP inspections varies between 60 and 120 months and repeat intervals vary between 36 and 120 months. The fact that inspections with the same implementation threshold can have different repeat inspection frequencies means virtually no two inspections occur at the same time. Apart from making it impossible to summarise the CPCP, it also causes maintenance planning problems for operators. Most CPCP inspections have to be performed during C-checks and structural inspections since they require deep access.

The ageing aircraft programme comprises of about 25 SBs. Each of these has its own implementation threshold, the majority of which is 75,000 cycles or a calendar age which corresponds to either 1994, 1997 or 2001.

Some SBs have already been performed on the production line and so are not required for later build models (*see table, page 34*). Therefore, not only does each SB have its own implementation threshold, but it also has its own group of production line numbers to which it applies.

Aircraft with line number higher than 1,200 have few SBs to implement and there are hardly any to implement for line number higher than 1,600.

Operator experience

The average daily utilisation and average flight hour to flight cycle ratio is about 2,803 flight hours per year and 1,796 flight hours. Rolling 12 month data shows the fleet operating at a technical despatch reliability (TDR) of 98.9%.

Finnair's fleet achieved a 12 month 98.8% TDR to January 1998 and generates an average of 8:05 flight hours per day on an average flight cycle time of 1:40 flight hours. Finnair's highest TDR reached 99.1% in the 12 months to July 1997.

Besides airframe checks there is also the aircraft's line maintenance. The MD-80's line maintenance programme is based on a pre-flight check, a daily check and weekly check. The names of each check indicates the repeat interval of each. However some operators have managed to have the intervals extended.

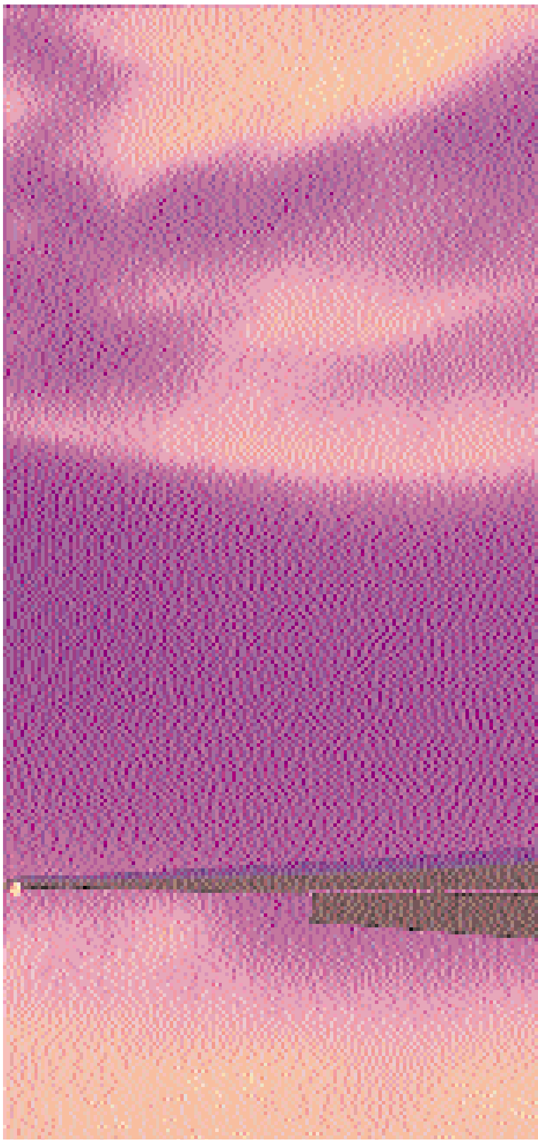
Swissair performs pre-flight checks before every flight. "This involves visual inspections, including a walk-around to check for obvious external damage, tyre checks and a flightdeck check. We perform this check at our Zurich base, but it is either done by engineers or the pilots at outstations," explains Marc Camenzind, manager engineering aircraft maintenance at SR Technics.

"The daily checks are more detailed, and usually done at night," says Camenzind. "The engines are checked inside the nose cone, oil levels are inspected and bearing temperatures examined. Other inspections included are the landing gear, tyres, spot lights, brake wear, doors, engine pylons, engine cowls, and taxi lights, as well as many other items.

"The weekly check is performed every 14 days and includes items such as oxygen bottles, engine exhausts, hydraulic fluids, actuators, brake indicators and landing gear doors," says

SUMMARY OF MD-80 AGEING AIRCRAFT SERVICE BULLETINS

Service Bulletin	Affected aircraft up to line number	Incorporation Threshold
27-262	1,243	September 1994
53-194	1,202	September 1994
57-178	1,157-1,173	September 1994
55-038	1,153	September 1994
29-044	1,338-1,500	September 1994
55-041	1,436	January 1997
53-213	1,424	January 1997
55-039	1,138	January 1997
78-041	1,067	January 1997
52-142	1,095	January 2001
A27-308	909-1,744	January 2001
55-042	1,588	75,000 flight cycles
53-216	1,248-2,043	75,000 flight cycles
53-186	1,248	75,000 flight cycles
52-188	1,241	75,000 flight cycles
52-138	1,141	75,000 flight cycles
27-240	1,126	75,000 flight cycles
53-147	1,126	75,000 flight cycles
52-135	1,115	75,000 flight cycles
52-125	1,053	75,000 flight cycles
27-209	1,039	75,000 flight cycles
56-011	1,037	75,000 flight cycles
57-143	988	75,000 flight cycles
A55-031	993	75,000 flight cycles
53-142	1,157	75,000 flight cycles



Under a MSG-2 programme, airframe and component maintenance should cost in the order of $550 per flight hour. The number of operators which have switched to a MSG-3 programme is about 50%.

Camenzind. "The pre-flight check consumes about half a man-hour, the daily about two man-hours and the weekly in the region of 18.5 man-hours."

The predicted routine man-hour consumption for airframe check inspections are escalated by the occurrence of non-routine repairs, cleaning, interior and cabin work, modifications and peculiar items.

Under a MSG-2 programme, the total number of man-hours consumed for an A-check is about 103. This rises to about 2,000 for a C-check. This is expected to fall to about 80 flight hours under the MSG-2 programme.

Swissair, which has incorporated MSG-3 principles into its A and C-checks, has intervals of 120 days and 4,500 flight hours or 16 months for its A and C-checks. It uses about 100 manhours for an A-check and 1,200 for a C-check.

"The A-check interval we have for our MD-80 means it is more efficient than the A320," says Paul Graf, division manager of line maintenance at SR Technics. "Our extended A-check interval of 120 days for the A-check means we could generate about 800 flight hours, while we are only permitted a 500 flight hour interval on the A320. This is a considerable difference when the 15 to 20 year older age of the MD-80 is taken into account. The A320 has easier and quicker pre-flight checks. The MD-80 and A320 have a similar C-check interval, while the MD-80 consumes about 50% more man-hours."

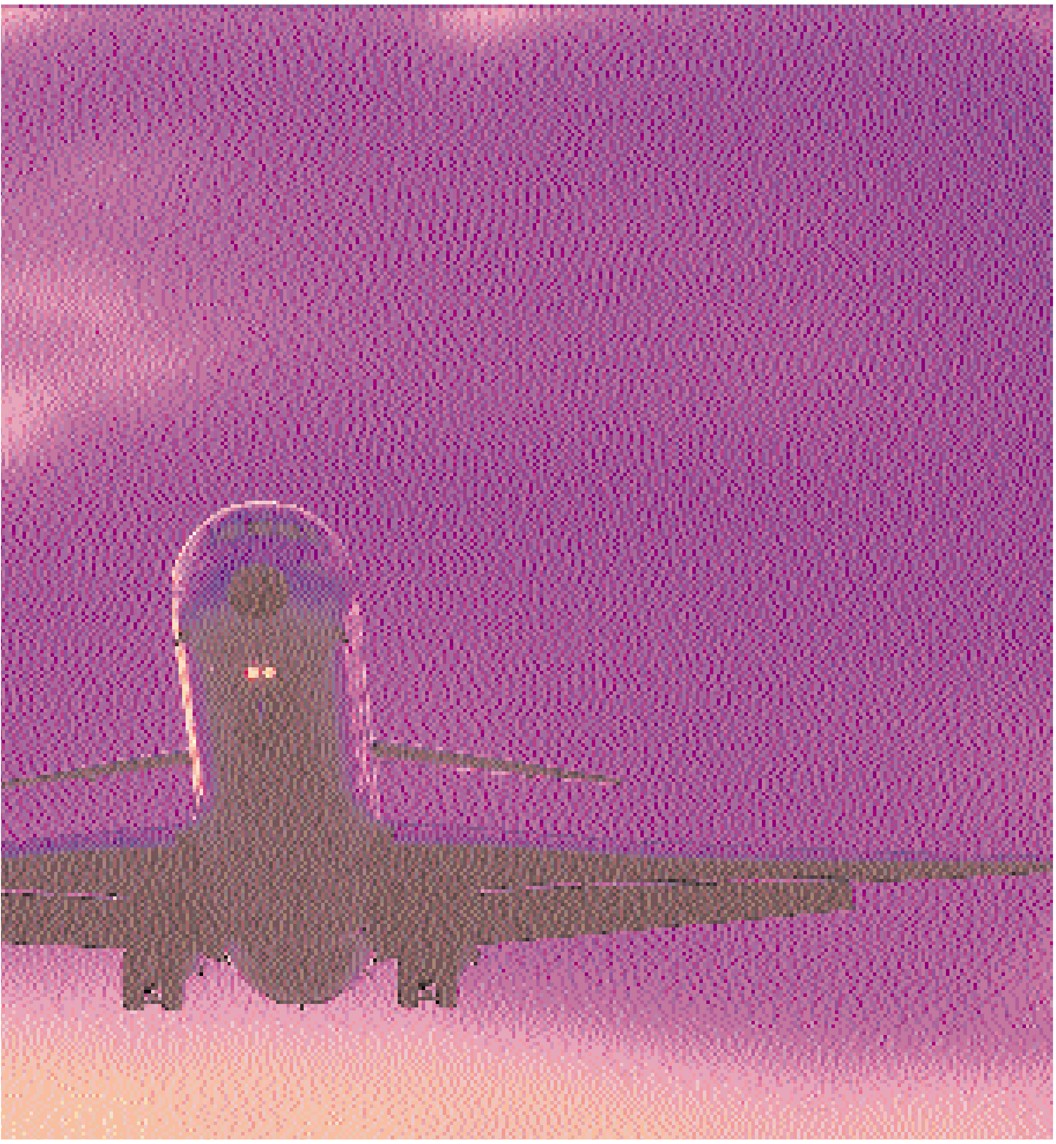
Finnair, which has a maintenance programme close to the original MSG-2 schedule, uses between 100 and 125 man-hours during an A-check and 1,200 to 1,500 man-hours in a C-check.

Routine man-hours required for a 15,000 flight cycle, or intermediate check, are more variable but are about 5,000. Finnair consumes 16,000 man-hours during an intermediate check and has an interval of 16,000 flight hours or 66 months. Similar to Finnair, SR Technics has an interval of 15,500 flight hours or 60 months. The calendar limits and annual utilisation of most carriers means most will not be able to achieve the full flight hours allowed by these intervals.

SR Technics records between 17,000 and 20,000 man-hours for the aircraft it manages, which includes Crossair's, Spanair's, Edelweis' and Dinar Lineas Aeraes' fleets. SR Technics breaks down the intermediate check man-hour consumption into 9,000-10,000 for routine inspections, 5,000-6,000 for non-routine repairs, 1,000 for cleaning, 1,000 -2,000 for modifications and 1,000 for peculiar items.

The man-hour consumption in a D, or heavy, check is highly variable. The routine man-hour requirement is about 7,500. The actual number consumed is often much higher and also varies widely between carriers and from aircraft to aircraft. This is because workscopes vary, the interval between each one is long and different operators schedule different tasks in its checks.

Again, Finnair and SR Technics have flight hour and calendar intervals for their D-checks at 30,000 flight hours and 120 months. Because most operators achieve about 2,500 flight hours per year, they generate 28,000 flight hours in 120



months. This system means most carriers are likely to reach the 120 month calendar limit before the 30,000 flight hours.

Finnair records a man-hour consumption of between 20,000 and 22,000 man-hours for the heavy check.

Camenzind explains that as well as routine man-hour requirements increasing every time a check is repeated, the amount of routine inspections also increase. This is partially explained by higher incidences of CPCP and ageing aircraft modifications.

Paone estimates that under the MSG-3 programme, the C-checks amalgamated with the multiple structural checks at 15 month intervals will consume between 2,200 and 2,500 man-hours, representing a large saving.

The material consumption commensurate with these checks is of several categories. These can be materials used in the performance of the checks, use of consumable materials and the repair of on-aircraft and off-aircraft rotables while the check is being performed. SR Technics includes all categories in its estimates of material consumption. "A C-check requires between $14,000 and $20,000 of materials while an intermediate check uses about $400,000 of materials and a D-check $800,000 of materials," says Camenzind.

Components

Besides check materials and consumables, rotables are a major cost item. The repair cost of on-aircraft rotables is included in the airframe check material costs. The ongoing off-aircraft rotable repairs have to be considered separately.

Off-aircraft rotables include the ownership and repair of line replaceable units (LRU), landing gears, the auxiliary power unit (APU), wheels, tyres and brakes.

The MD-80's landing gear is standard for all four variants. The standard MDC part numbers are 5930593 and 5930999 for the main landing gear and 5910446, 5920447, 5940336 and 5940337 for the nose gear. These are not available to operators directly from the vendor, but must be purchased direct from MDC. The landing gear is completely interchangeable between the four MD-80's variants at their standard published weights.

Landing gear overhaul interval is 16,000 flight cycles or 10 years for the nose gear and 20,000 cycles or 10 years for the main gear. Given that most operators achieve not more than 1,100 cycles per year, landing gear removal will not be more frequent than every 10 years. Minimum repair cost is about $150,000 per set but can be two or three times that amount.

The APU used universally by all MD-80 variants is the Allied Signal GTCP-8-95D. It is difficult to determine average flight hours between removals although average on-aircraft time is about 4,200 APU hours. Considering the APU will be on during turn time, which might be 45 minutes, and for about the first ten minutes and last five minutes of block time, the utilisation would then be at least one hour per cycle. On an average cycle time of about one-and-a-half flight hour per cycle, the APU therefore would be used for about 40 minutes per cycle. An average on-aircraft time of 4,200 APU hours therefore is equal to about 5,500 flight hours.

Repair cost can be $50,000-$100,000 depending on workscope and LLP requirements but an average of $75,000 every 5,000 flight hours would provide a conservative budget.

The wheel and brake assemblies, part numbers 5004321-14 and 5004320-8, are interchangeable between all MD-80 variants like the landing gear. The brakes are supplied by Bendix.

Tyres can have re-treads made a maximum three times. Camenzind puts the cost of each re-tread at $270 for each nose tyre, while he estimates a re-tread for a main gear tyre at $400. The total cost for a full re-tread would therefore be $2,140. Re-treads are required after about 140 landings for the nose tyres and about every 170 landings for the main gear tyres.

Camenzind puts the cost of each new tyre at $700 for a nose gear and $1,200 for a main gear tyre. New tyres last about 170 landings until the first re-tread becomes necessary.

There is therefore an average cost of tyre re-treads and replacements of $3,155, which on average is required once every 160 cycles.

Brake repairs are of course only required for the main gears. Camenzind estimates the repair cost for each brake unit is about $8,000-$10,000 and so a total cost of $40,000 is expected for the aircraft's four brake units. Brake repair intervals are about 700 landings for the highest gross weight MD-83s and about 1,300 for the lowest gross weight MD-81.

The cost of acquiring, owning and continual repair costs for an LRU

MD-80 FLIGHT HOUR MAINTENANCE RESERVES-MSG-2 PROGRAMME

Item	Interval	Man-hours consumed	Man-hours cost ($)	Materials used ($)	Total cost ($)	Per flight hour cost ($)
Pre-flight check	Per cycle	0.5	25	10	35	21
Daily check	24 hours	2	100	40	140	20
Weekly check	7 days	19	950	200	1,150	23
A-check	600 FH	100	5,000	2,000	7,000	12
C-check	15 months or 3,250 FH	1,500	75,000	18,000	93,000	29
IV-check	60 months or 13,000 FH	18,000	900,000	400,000	1,300,000	100
D-check	120 months or 26,000 FH	26,000	1,300,000	800,000	2,100,000	81
APU repair	5,500 FH				75,000	14
Landing gear repair	10 years				200,000	8
Brake repair	1,000 cycles				40,000	24
Tyre replacement and re-tread	Approx 160 cycles				3,155	12
LRU-PBH rate						200
Total cost per flight hour						**530**

This table is based on an annual utilisation of 2,600 flight hours, 1,557 flight cycles and an average flight time of one hour and 40 minutes.

inventory is variable, depending on the fleet size and method of acquisition and management.

AAR puts the outlay for a LRU inventory for five aircraft at about $8-$9 million. A small operator is now more likely to opt for a power-by-the-hour (PBH) agreement or a mixture of paying a spares supplier repair and lease charges or exchange fees. A PBH agreement for an MD-80 is likely to cost in the region of $200 per block hour.

LRUs include avionics, which are interchangeable across all variants, except the MD-88 which uniquely has an Efis flightdeck. The MD-88 should experience higher reliability and lower failure rates, leading to lower costs compared with other models.

Larger operators endure the cost of owning, repairing and holding their own inventory. A PBH rate includes not only all these cost elements but a profit margin as well.

Maintenance reserves

An estimate of airframe maintenance costs per flight hour can therefore be made from all the elements described above together with their maintenance intervals. This is based on an aircraft operating on a MSG-2 maintenance schedule.

The table uses a typical operation as a basis for calculating costs per flight hour and assumes an average flight cycle time of one hour and 40 minutes and annual utilisation of 2,600 flight hours and 1,557 cycles.

This annual utilisation determines the flight hours achieved between most elements of maintenance, which do not have fixed flight hour interval.

All labour is assumed to have an average cost of $50 per man-hour. Each facility and airline will have its own man-hour rates and this will be the largest influence on final maintenance costs.

The three line checks are assumed to incur material costs equal to about 40% of the labour cost, escalating total cost for each check. The maintenance schedule is assumed to require a pre-flight check for each flight, a daily check every 24 hours and weekly check every 7 days. This takes cost per flight hour for these three checks to $64.

The A-check is also assumed to have a material cost factor of 40% of labour cost, consume 100 man-hours and an interval of 600 flight hours. This adds a cost per flight hour of $12.

On the basis that a C-check is done every 15 months, the interval between each one is 3,250 flight hours. A man-hour requirement of 1,500 and material cost of $18,000 adds another cost per flight hour of $29.

An MSG-2 schedule is used for the IV and D-check structural inspections, with modified intervals of 60 and 120 months. These checks then occur every 13,000 and 26,000 flight hours.

Man-hour use for the IV check is taken at what is probably a global average of 18,000 man-hours and a material consumption of $400,000. This is a check cost of $1.3 million and an equivalent cost per flight hour of $100. This may prove conservative since man-hour requirements could rise with age.

Man-hours for the D-check are put at 26,000 and material use at $800,000. This cost of $2.1 million generates a flight rate of $81.

LRUs are simply costed at the PBH rate of $200 while the APU cost of $75,000 per repair every 5,500 flight hours generates a cost of $14 per flight hour.

The 10 year interval and $200,000 repair cost for landing gear results in a cost of $8 per flight hour.

Brakes are repaired at 1,000 cycles, the interval for an "average" MD-80 variant. At $40,000 this puts cost per flight hour at $24. Finally the cost of replacing and re-treading tyres generates an average cost per flight hour of $12.

Total flight hour costs are then about $545 which is close to the cost of the same items for 737-300 maintenance. The MD-80 has reasonable and non-excessive costs for its age and technology generation.

The estimate that C-checks amalgamated with structural inspections will consume about 2,500 man-hours sees a large reduction in man-hour use. Even when the crude assumption is made that the material used for the IV and D-checks is not altered by this process, the labour saving reduces total cost per flight hour to about $440.

This analysis and the potential savings from moving to a MSG-3 maintenance programme show that potential operators of used MD-80s should have nothing to fear from excessive and escalating airframe and component-related maintenance costs. It further indicates that, like other MDC aircraft, the MD-80 could still have many years of operation remaining. It all depends on the market finding a suitable use for the aircraft. AC