While the current narrowbody fleet is a mixture of several types, fast rates of retirement of older types and high delivery rates of A320s and 737NGs means they will dominate the fleet and so the narrowbody base maintenance market in 10 years.

A320 & 737 NG families to dominate narrowbody maintenance market

Base maintenance for narrowbody mainline jets is one of the largest revenue streams for maintenance providers. The global fleet of aircraft from the same size as the DC-9 or 717 and up to the 757-300 will clearly be dominated by the 737NG and A320 families. Predictions are that by 2008 these two types will account for half of the narrowbody fleet, and about 66% of the fleet by 2014. The fleet will have also grown by about 35% by 2014. This increase will result in a rise in the volume of C and D or heavy checks for these aircraft. How the development of the narrowbody fleet affects the actual annual volume of base checks for each type is analysed here.

C & D check volumes

The aircraft types in the narrowbody fleet are a mixture of old and current generation aircraft which have maintenance steering group 2 (MSG2) and MSG3 maintenance programmes. The MSG2 programmes of older generation aircraft are based on the concept of pre-defined work packages for C and D or heavy checks, which have pre-defined intervals. These generally conform to a sequence of up to six or seven C checks followed by a D or heavy check. C check intervals range from 12 to 18 months for most aircraft types. D/heavy checks are performed on the oldest generation aircraft every four or five years, while a few types have intervals of between seven and 10 years.

Many operators have stayed relatively close to these maintenance programmes, although extensions to C and D check intervals are possible for individual operators.

Some airlines have chosen to phase or 'equalise' their C and D/heavy C checks, which results in C and D/heavy C checks being broken into smaller packages of work that result in shorter periods of downtime.

Size of checks

Ageing aircraft programmes have added to C and D checks in MSG2 programmes, as the aircraft continue in operation at an old age and structural problems are found. The two largest areas of ageing aircraft programmes have been corrosion prevention and control programmes (CPCP) and the supplemental structural inspection document (SSID). These inspections do not have the same intervals or frequency as C and D checks, and have had to be added to base checks, thereby increasing their workscopes.

Younger generation aircraft have MSG3 maintenance programmes. These are based on having intervals for individual tasks and allowing operators the convenience of grouping these tasks

The A320 family is expected to be the most popular narrowbody aircraft type by 2014, and consequently will generate the highest volume of base checks.

NARROWBODY FLEET FORECAST DEVELOPMENT 2004-2014

Aircraft type/family	2004	2009	2014
720/707/DC-8	261	107	42
727-100/-200	607	424	317
737-100/-200	624	512	215
DC-9	404	205	12
Sub-total	**1,896**	**1,248**	**586**
737-300/-400/-500	1,916	1,948	1,912
757-200/-300	1,005	1,022	970
MD-80/-90	1,149	1,212	1,047
Sub-total	**4,070**	**4,182**	**3,929**
717	137	177	201
737NG family	1,622	2,819	4,047
A320 family	2,328	3,709	4,994
Sub-total	**4,087**	**6,705**	**9,242**
Grand total	**10,053**	**12,135**	**13,757**

Source: Aerostrategy

into checks to suit their operation. The concept of MSG3 disposes of a fixed pattern of checks with fixed groups of tasks.

There remains a group of structural inspections that can result in a heavy C check. These are still referred to by some operators as a 'D' check, but with a few aircraft types they are effectively larger C checks. Most aircraft types therefore still have C checks with similar intervals to those in MSG2 programmes, while 'D' checks are heavy C checks or structural inspections.

MSG3 maintenance programmes have incorporated ageing aircraft inspections into base checks. The initial threshold for some ageing aircraft inspections is relatively high, so the workscope of base checks increases as aircraft age.

The C check intervals for aircraft with MSG3 maintenance programmes are a little longer than for aircraft with MSG2 programmes. Younger and current generation aircraft types, however, have noticeably longer heavy check intervals than older types.

Interval utilisation

Besides check intervals, another factor that affects the overall number of base checks required for a fleet is the portion of the check interval that is actually utilised, which can be relatively high (up to 85-90% of the actual interval). Airlines are also constrained, however, by the need to spread the timing of checks. They are also affected by operating schedules and can only schedule aircraft for maintenance during periods of low traffic volumes. This can often mean performing checks at a similar period each year, and so achieving a lower utilisation of a 15-month or 18-month C check interval.

C and heavy check schedules are interdependent, so early production of C checks results in performing D checks early compared to their full interval. An example is the A320, which has a C check interval of 15 or 18 months. There are two structural inspections, the first of which is performed at the fourth C check at an interval of five years. The second and heavier structural check has an interval of 10 years and is performed at the eighth C check. If C checks are performed every 15 months then the full five and 10 year intervals for the structural checks can therefore be utilised. Performing C checks annually, however, means that the two structural checks will have to be performed at four and eight years, so the full interval is lost.

Additional demand

As well as regular scheduled C and heavy checks, additional maintenance is generated by 'casualty' events or unscheduled maintenance, and by aircraft requiring maintenance at the end of leases. Lease return conditions can often require aircraft being returned to lessors on a standard maintenance programme or a new maintenance schedule for the next operator. Bridging maintenance will be required to take the aircraft from an existing maintenance programme to a new one. It is normal for lease return conditions to require an aircraft to be returned to a lessor in a maintenance status equal to zero time after the heavy check, irrespective of the actual time since or remaining to a heavy check.

Other factors at the end of a lease that generate additional requirements for maintenance are: the need to reconfigure the interior and cabin for a new layout; bridging maintenance required when an aircraft changes registration; and maintenance if the aircraft has been in an extended period of storage.

Fleet development

A summary of the forecast development of the narrowbody fleet up to 2014 is shown *(see table, this page)*. This shows an overall growth of 37% over the 10 years from 2004 to 2014. The fleet can be split into three main groups.

A320 & 737NG families, 717

The first of these groups comprises the current generation narrowbodies still in manufacture. This only includes the four members of the A320 family, the four members of the 737NG family and the 717.

The popularity of the A320 and 737NG families is illustrated by the number of annual deliveries up to 2004, and the forecast rate of deliveries up to 2014. Their numbers are forecast to increase by a factor of 2.3 from a fleet of 3,950 in 2004 to a fleet of 9,000 by 2014. This represents an average annual delivery rate of 510 for these two types.

The A320 is expected to dominate throughout this period, with annual deliveries averaging 270. The 737NG fleet is forecast to grow at a similar rate, but in smaller numbers than the A320 family, based on market shares for the two types in recent years.

This forecast does not consider aircraft that Airbus and Boeing will offer as replacements for the A320 and 737NG families, since these are not expected to enter service until at least 2012. Production rates of these new types will be low until 2014. The fleet forecast data for the A320 and 737NG families includes these two new types.

The 717 failed to sell in large numbers, but it is a niche aircraft that is often operated by airlines that do not require different aircraft sizes of family members like the A320 or 737NG.

The 717 is still expected to sell in small numbers, but the fleet will only reach about 200 *(see table, this page)*.

All aircraft types in the two remaining groups are no longer in production.

Numbers of 757s are forecast to remain stable over the next 10 years. While the aircraft will account for a small portion of the narrowbody fleet, it will be one of five types, along with the A320 family, 737 family, 737 Classics and MD-80/-90 to dominate the narrowbody base maintenance market.

737 Classic, 757 & MD-80

The first group of narrowbodies no longer in production is the mid-generation aircraft that includes the 737-300/-400/-500 family and 757, manufacture of which has ceased in recent years. This group also includes the MD-80/-90, production of which ceased in 1999 and 2000.

The number of each of these types in operation is expected to remain stable over the next 10 years. The 757 and 737-300/-400/-500 series are all popular types and demand for them remains strong.

The 737-300/-400/-500, or 737 'Classic', is in the highest demand after the A320 and 737NG. The 737 Classic is simple to operate, has an ample level of technical support in the market place and provides airlines with good economics. It is the prime choice of used narrowbody aircraft for airlines and lessors. This is illustrated by the recent shortage of the type following the rebound in global traffic and increased demand for aircraft.

While some -300 and -400 aircraft will be converted to freighter, most will remain in operation as passenger-configured aircraft. The number of operational aircraft is unlikely to change much from the current fleet of 1,950 units.

The 757 is in a class of its own, although it has fallen somewhat out of favour in recent years. The type has also entered the used market and conversion of the first aircraft to freighter has begun. The payload and operating cost characteristics of the 757 freighter compared to the 737-300/-400 mean the 757 will be a popular type among freight carriers, and a large number should be converted, thereby ensuring their future operation.

Large numbers of 757s will remain in operation with US major carriers, with the youngest aircraft in the fleets of Continental, American and Northwest being less than five years old. All five US majors have 757s manufactured in the late 1990s and have all had fleet policies of operating large portions of their mainstream narrowbody fleets for 25-30 years before retiring them. The 757's uniqueness will also secure its future, and it will become a popular type in the used market as an alternative to smaller widebodies which have higher cash operating costs.

The MD-80/-90 have so far remained popular. The original MD-80 production of 1,194 units was concentrated among nine principal users. Two of these, American and Delta, now account for about 450 of these aircraft. Other MD-80s have been dispersed by original operators and the number of users has increased. While the MD-80 has a durable airframe and engines with low maintenance costs, it lacks the global appeal and flexibility of different family sizes that the 737 Classic has. It is hard, for example, to get an AOC for the MD-80 in several Eastern European countries.

The MD-80 has remained with some of its original European operators, in particular Alitalia, SAS and Iberia. Other airlines like Finnair and Swissair have phased out the bulk of their MD-80 fleets.

The MD-80 is second favourite to the 737 Classic. There is no passenger-to-freighter modification for the MD-80/-90, however, so it depends entirely on the used passenger aircraft market for support.

Demand for the MD-80 will only be strong if airlines do not retire older aircraft at a high annual rate. Overall, the MD-80 fleet is expected to remain relatively stable with only about 100 retirements over the next 10 years.

Old generation narrowbodies

This third group includes the 707, DC-8, DC-9, 727 and 737-200, the last three of which are the most important types.

The 707 and DC-8 are still being operated by freight airlines, but their number will continue to decline quickly. They will generate mainly C checks, since the majority of aircraft will be retired once they reach their next heavy check.

The 727 and 737-200 operate in similar numbers of about 500units each. These are a fraction of the original numbers produced.

The 727 is operated primarily in a freight role, and in most cases flies at low rates of utilisation. The 727 is slowly being replaced with newer types. Large numbers of 727s are still operated by FedEx and UPS, both of which have yet to select a replacement. While UPS will gradually replace its 727s with larger types as traffic volumes grow, FedEx has postponed its replacement decision several times. Even if this is made soon, it will take several years to replace its fleet of 110 aircraft.

While 300 727s are predicted to still be in operation by 2014, a high rate of older narrowbody replacement by passenger airlines will result in a large number of 737-300s, 737-400s and 757s being dumped onto the used market. This will lower their values, which will accelerate the rate of retirement of 727s.

The 737-200 fleet is divided between those that have been modified for Stage 3 compliance and those that have not. Modified aircraft will remain popular, but many have accumulated a high number of flight cycles and will come due for a lot of ageing aircraft inspections and

NARROWBODY ANNUAL BASE CHECK ACTIVITY FORECAST 2004-2014

Aircraft type/family	2004	2009	2014
A320 family	1,862	2,939	4,015
737NG family	1,086	1,998	2,955
737-300/-400/-500	1,667	1,695	1,663
757-200/-300	804	818	776
MD-80/-90	919	970	838
Sub-total	**6,338**	**8,420**	**10,247**
717, 720/707/DC-8, 727-100/-200, 737-100/-200 & DC-9	950	600	250
Grand total	**7,288**	**9,020**	**10,500**

modifications over the next few years that will force their retirement. Only about 200 are forecast to be in operation by 2014.

The DC-9 is well known for its durable airframe and stable maintenance costs. Many of the fleet have been modified to comply with Stage 3 noise compliance. The global operational fleet is about 350, having declined from 400 operational aircraft at the end of 2004. The two major fleets are Northwest Airlines and ABX Air, currently accounting for 217 of all DC-9s in service. Although Northwest has put its DC-9 fleet through a life extension programme, its fleet is now steadily being replaced and will be fully retired by 2012.

ABX is similarly expected to have retired all its DC-9s by 2013. Virtually all DC-9s will have been phased out by 2014.

Base check activity

As described, the A320 and 737NG families will increase over the next 10 years. Numbers of old generation aircraft will decline to less than one-third of their current numbers over the same period. The narrowbody jetliner fleet will increase by about 3,700 units overall.

By 2014 the A320 and 737NG families will account for about 66% of narrowbodies. About 1,900 737 Classics will remain in operation, however, and about 6,000 CFM56-powered 737s will be in service at this stage. This will be followed by about 5,000 A320 family types.

The remaining 3,000 narrowbodies in operation at this stage will represent a minority of the fleet, but include about 1,000 757s and 1,000 MD-80/-90s. This clearly illustrates which types will dominate the base check market.

A320 family

The first A320s were delivered in 1988. Deliveries between 1988 and 2004 averaged 137 units per year. Future delivery forecasts expect A320 family aircraft to be higher than the 737NG, putting A320 family deliveries at an average of 270 per year. This is due to several factors, including the narrowbody market being left to two main types in the future and the high capacity growth of low-cost airlines.

Like all Airbus aircraft, the A320 has a base maintenance schedule of eight C checks, each with an interval of 15-18 months, and the fourth and eighth coinciding with the heavy checks: the IL and D checks. These have intervals of 4-5 and 9-10 years.

The first IL checks were performed on the oldest A320s in 1992 and 1993 as these aircraft reached their fourth or fifth birthdays. The earliest aircraft had their first D checks in 1996 and 1997. The fleet had increased to 550-600 units by this stage, meaning the global A320 fleet was generating about 250 IL and D checks each year.

The oldest A320s had their second IL checks performed in 2000 and 2001. This coincided with the first IL checks for aircraft built between 1995 and 1997, and increased the annual number of IL and D checks. The number of these checks was further boosted in 2004 and 2005, as the earliest built aircraft came due for their second D checks at 16-17 years of age, which coincided with aircraft built between 1995 and 1997 coming due for their first D checks. This will have increased the annual number of IL and D checks to about 500 per year. The number will also increase thereafter as each year more aircraft come due for their first IL and D checks.

While the average interval between subsequent C, IL and D checks on the A320 is 15 or 18 months, actual utilisation of base check intervals will be closer to an average of about 14 months for all operators. This implies that in 2004 about 1,860 base checks would have been required by the global fleet. This number will increase as the fleet grows, with the annual number of base checks reaching 3,000 in 2009 and 4,000 in 2014 *(see table, this page)*.

737NG family

The first deliveries of the 737NG family aircraft were in 1997, but their number began to reach high levels in late 1998. Annual deliveries averaged 230 aircraft per year up to 2004, equal to almost 20 aircraft per month. Deliveries are forecast to continue at similar rates, although actual numbers will depend on the share of the market the 737NG has compared to the A320 family.

The fleet of 737NGs totalled about 1,600 at the end of 2004, and is expected to reach about 2,800 at the end of 2009 and more than 4,000 in 2014.

The 737NG's base maintenance programme arranges task intervals in phases. The interval for basic items varies by operator, but is between 15 and 24 months. Successive C checks are at multiples of these C checks. The heaviest C check is either at a multiple of four, six or eight of the basic C check interval. These heavy checks have an interval of 96 to 144 months. The average actual C check interval will be in the region of 15-16 months. This implies the first heavy checks will be seven or eight years after initial service entry, and so will occur in 2005 and 2006. Some of the earliest built aircraft will not go through their first heavy check until about 2008 or 2009.

The first 737NGs were delivered in considerable numbers in 1998, so the first C1 checks followed in 1999. The delivery pattern of the first delivered aircraft means that only about 180 light checks would have been performed during 1999. The number of annual base checks increased to about 1,100 in 2004 *(see table, this page)* and to about 1,500 by 2006, including some of the first heavy C checks.

By 2009 the number of annual base checks will have increased to about 2,000, and will increase to about 3,000 by 2014 *(see table, this page)*. By 2012 the earliest built aircraft will be coming due for their second heavy C checks.

The 737NG has been ordered in large numbers by low-cost airlines. Annual sales have been similar to the A320, and numbers of 737NGs will exceed 737 Classics in two to three years, making the 737NG the second most numerous narrowbody.

737-300/-400/-500

The 737-300/-400/-500 family has a block maintenance programme with a series of C checks that go up to the C6, the heavy check in the series.

The basic C check interval is 15 months for most operators, but is 18 months in some cases. The actual average interval across the fleet is 13-14 months.

Fleet numbers of the 737-300/-400/-500 family had matured by 2004 to about 1,900 aircraft. Given the average interval of 13 months between base checks, about 1,670 base checks can be expected to be performed each year *(see table, page 48)*. The prediction that fleet numbers are expected to remain stable means the number of base checks will remain at about this level until 2014.

757-200/-300

The 757-200/-300 has a block base check maintenance programme with system- and structural-related checks. These have intervals related to flight hours (FH) and flight cycles (FC). The 1C structural C check can either be combined with the 1C or 2C system check, depending on the aircraft's FH:FC ratio in operation. Most operators choose to keep the system and structural checks in phase for the sake of simplicity.

The 1C check has an interval of 18 months and 6,000FH, with the calendar limit being reached first in most cases. The C4 check is the heaviest check, and has an interval of 72 months and 24,000FH.

The actual achieved interval is about 15 months, with the heavy check occurring about once every five years.

The number of 757s in service reached just over 1,000 by the end of 2004. With production ceasing in the first half of 2005, the number of aircraft in operation will only increase to about 1,020.

An average base check interval of 15 months means the fleet will require about 800 base checks per year in 2004 and 2005, with one quarter of all checks being heavy C checks. The small decline in 757 numbers by late 2014 will lead to a small decline in the number of checks.

MD-80/-90

The MD-80's maintenance programme is similar to the A320's. The base check programme has three C checks, followed by a smaller structural check, then another three C checks and finally a D check. The interval between the subsequent checks is 18 months, with the full cycle to the D check having an interval of 10 years. An average achieved interval of 15 months will see the full cycle being completed after nine or 10 years.

By 2004, the MD-80/-90 fleet was stable at about 1,150 units. This generates about 900 base checks each year, a quarter of which are structural checks. The predicted stability of MD-80/-90 fleet numbers means the number of annual checks will remain at current levels for about another eight years.

Summary

The number of base checks for the A320 family, 737NG series, 737 Classic, 757 and MD-80/-90 was about 6,338 *(see table, page 48)*. This increased by about 950 checks for the 717 and group of oldest narrowbodies.

The number of annual base checks for the five main aircraft types will have increased to about 10,250, an increase of 62% *(see table, page 48)*. The number of checks for the whole narrowbody fleet will be about 10,500.

The increase of almost 4,000 checks will therefore be accounted for by growth in the A320 and 737NG families. The A320 family will have doubled, while the 737NG will have nearly trebled in size.

The 737NG and 737 Classic will together require about 4,700 base checks per year, making it the single largest market. It also represents about 44% of the narrowbody base maintenance market.

These 4000 checks are split between about 3,000 for the 737NG family and 1,700 for the 737 Classic family.

The 4,000 annual base checks for the A320 family will represent 38% of the narrowbody base maintenance market, but the largest market for a single type. One quarter of these checks will be IL and D checks.

The number of base checks for the 757 and MD-80/-90 will have remained almost constant with the current level, at about 800 checks each per year.

The high cost of ferrying narrowbodies between continents in relation to the total cost of the checks means most aircraft will have their base checks performed in the continents of their domicile.

The largest volume of base checks will therefore be in North America and Europe. In turn, a large portion of A320 family and 737 fleets in the US, Canada and Europe are operated by major airlines, which perform their own maintenance. This will limit the potential market for third-party maintenance providers. It is nevertheless clear which will be the most important aircraft types in the future. AC