Airlines and operators are looking to a new, more fuel-efficient generation of narrowbodies. An initial assessment of the A320neo, 737 MAX and Bombardier CSeries is made. Technologies, probable fuel burn and operating cost-reduction features are reviewed.

New narrowbodies assessed: A320neo, 737 MAX & CSeries

Two narrowbody families, the 73NG and the A320, dominate the market. Older narrowbody types such as the DC-9, MD-80, and 757 are being phased out. While 737NG and A320 order books are still full, airlines have begun looking at the next generation of narrowbodies in their continuous quest to lower overall operating costs.

Boeing and Airbus have launched their next generation narrowbody families: the 737 MAX and A320 new engine option (A320neo). Both of these families are based on the same models as their predecessors, but will utilise new engines. These are provided by the high bypass ratio engines from CFM International (the CFM LEAP, for both the 737 MAX and A320neo); and by Pratt & Whitney (PW1100G for the A320neo). These engines are set to provide many of the efficiencies promised with these new aircraft, particularly reductions in fuel burn. This is especially important for airlines, because there is a good chance that fuel costs will remain high for the foreseeable future.

The advantage of re-engining a current design is that many airlines have the current 737NG and A320 families in their fleets, and so already have the facilities and processes in place to maintain and operate them. Fuselage lengths and door configurations (and therefore potential passenger seat configurations) for the 737MAX and A320neo will remain the same as the current generation aircraft. This means the new aircraft will easily replace current aircraft.

Bombardier, however, has entered the lower end of the mainline narrowbody market with a 'clean-sheet' design, and is currently in the latter stages of developing the CSeries.

The CSeries is an all-new aircraft type with two main models that will seat 100-145 passengers, depending on the model and seat configuration. This means the CSeries family will not compete directly with the 737MAX and A320neo families.

The 737 MAX-7 and A319neo in lower-density seating layouts may compete, however, with the larger variant of the CSeries, the CS300, when configured in a high-density layout.

The CSeries will benefit, however, from new technology and manufacturing methods throughout, as well as new engine technology. This should allow it to offer lower seat-mile costs compared to current generation aircraft of a similar size.

The CSeries has significant use of composite materials in its structure, which helps to reduce its weight and fuel consumption. The use of composites also allows larger windows and improved cabin comfort which improve passenger satisfaction.

The 737 MAX and A320neo will be used on mainline operations only. The CSeries is placed to fill the gap between large regional jets (RJs), such as the E190/195 and CRJ900/1000, and small mainline jets, like the 737-600/-700 and A318/A319. The CSeries is also a lower weight alternative to the smaller members of the 737 and A320 families.

A320neo

The A320neo family was launched in December 2010, and is due to enter service in October 2015.

There are three variants of the A320neo family: the A320neo itself; the smaller A319neo; and the larger A321neo. These three have the same fuselage size as their counterparts in the current A320 family. The smallest member of the current A320 family; the A318, will not have an equivalent neo variant.

The A320neo will have a standard dual-class seat configuration of 150, but will be certified up to 180 seats in single-class configuration *(see table, page). The* A320neo will also be able to carry seven LD-3 cargo containers in 1,321 cubic feet of volume *(see table, page 30)*.

The smaller A319neo will have a dual-class layout of 124 passengers, and a single-class layout of up to 156. An extra five LD-3 freight containers can be accommodated *(see table, page 30)*.

The larger A321neo has a dual-class seat configuration of 185, and a single-class configuration of up to 220. The A321neo can also carry up to 10 LD-3 cargo containers in the underfloor space *(see table, page 30)*.

The three A320neo family members will have two gross weight and two fuel capacity options *(see table, page 30)*.

There are two engine options for the

The A320 and 737 families have enjoyed a near monopoly for more than a decade. New developments of these families will now face direct competition. The first competitor is the Bombardier CSeries, but this will be joined by the COMAC 919 and the Irkut MC-21.

three A320neo variants: the CFM LEAP-1A and the PW1100G.

The CFM LEAP-1A engine will have a thrust rating of 24,500lbs to 32,900lbs *(see table, page 30)*.

The PW1100G is rated from 24,000lbs to 33,000lbs. The PW1124G powers the A319neo, with a take-off thrust rating of 24,000lbs. The PW1127G will power the A320neo, and is rated at 27,000lbs of thrust. The PW1133G will power the A321neo, and will be rated for a take-off thrust of 33,000lbs *(see table, page 30)*.

The new engine types available for the A320neo are the largest differences with the current A320 family.

Other changes in the aircraft mainly concern the new engines. The wing structure and fuselage will be altered to accommodate the new engines, while the centre wing box will be reinforced. The A320neo will also have Airbus's new winglet devices, named sharklets.

Airbus has used the philosophy of minimum changes for maximum commonality between the new A320neo and the older A320. This means they will share the same type certification and type rating. This reduces the A320neo's introduction costs for airlines currently operating the A320, since they will already have pilot training, facilities and processes in place.

Airbus says that the A320neo will provide annual fuel savings of 15% compared to current generation A320 family aircraft *(see table, page 30)*. This equates to an annual saving of 1.4 million litres (370,000USG) of fuel and $1.1 million.

Environmentally, the A320neo family will have NOx emissions 50% below CAEP VI margins. The A320neo's lower fuel burn means it will also emit 3,600 fewer tonnes of carbon dioxide (CO2) per year compared to current generation aircraft *(see table, page 30)*.

This has the potential to help operators in the European Union (EU) with costs associated with the Emissions Trading Scheme (ETS). Fewer emissions equate to lower ETS costs.

The A320neo family will also be 15dB below Stage IV noise regulations *(see table, page 30)*.

The A320neo family, despite being three years away from entry into service, has already attracted 1,459 firm orders *(see table, page 30)*. The largest orders are from Air Asia (200 aircraft), IndiGo (150), International Lease Finance Corporation (ILFC–100), and Norwegian Air Shuttle (100).

Engine orders for the A320neo are split almost 50/50, with 528 aircraft (1,056 engines) confirmed for CFM with the LEAP-1A, and 502 aircraft (1,004 engines) confirmed for Pratt & Whitney (PW) with the PW1100G. An engine choice has not been announced for the remaining aircraft on order.

737 MAX

The 737 MAX was first announced in August 2011, and is due to enter service in 2017. Southwest Airlines, which has operated all generations of the 737, will be the launch customer.

Like the A320neo, the 737 MAX is a re-engined version of a current generation aircraft.

There will be three variants: the 737 MAX 7, 737 MAX 8, and 737 MAX 9 *(see table, page 30)*. Like the current generation A318, the smallest 737NG member, the 737-600, will not be developed into a MAX variant.

The 737 MAX 7 will be the smallest member of the 737 MAX family, and will seat 126 passengers in a typical dual-class layout, and up to 149 in single-class configuration *(see table, page 30)*.

The 737 MAX 8 will have 162 seats in a two-class layout, and up to 189 in high-density, single-class seating.

The largest aircraft in the 737 MAX family will be the 737 MAX 9, typically accommodating 180 passengers in dual-class seating. The 737 MAX 9 can seat a maximum of 215 passengers in a one-class economy configuration *(see table, page 30)*.

These are exactly the same typical seating configurations as the counterparts in the 737NG family. This is because, like the A320neo family, the 737 MAX family maintains a lot of fleet commonality with the older 737NGs. Current 737NG operators can therefore use the 737 MAX as a direct replacement for their current 737NG fleet with relative ease.

Cargo volumes are also expected to remain the same on the 737 MAX as on the 737NG family, although this is yet to be officially confirmed by Boeing. If so, belly cargo capacities will be as listed *(see table, page 30)*.

Detailed weight and other specifications of the 737 MAX will be finalised in 2013, although the maximum take-off weights (MTOWs) of the three 737 MAX variants have been announced.

The MTOW of the 737 MAX 7 will be 159,500lbs *(see table, page 30)*, which is 5,000lbs heavier than the current 737-700.

Similarly, the 737 MAX 8 has a MTOW of 181,200lbs *(see table, page 30)*, 7,000lbs higher than the 737-800.

The 737 MAX 9 will also be 7,000lbs heavier than its predecessor, with a MTOW of 194,700lbs *(see table, page 30)*, compared to 187,700lbs for the 737-900ER.

The 737 MAX family will also have increased range compared with current 737NG members.

The 737 MAX 7 will have a maximum range of 3,800nm *(see table, page 30)*, which is 400nm longer than the 737-700.

The 737 MAX 8 will have a range of 3,620nm *(see table, page 30)*, compared to 3,080 for the 737-800.

The 737 MAX 9 will have a range

A320NEO, 737 MAX, & CSERIES SPECIFICATIONS

	A320neo family			737 MAX family			CSeries	
	A319neo	A320neo	A321neo	737 MAX 7	737 MAX 8	737 MAX 9	CS100	CS300
Typical seating	124	150	185	126	162	180	110	130
Maximum seating	156	180	220	149	189	215	125	145
Economy layout	3 + 3	3 + 3	3 + 3	3 + 3	3 + 3	3 + 3	2 + 3	2 + 3
Cargo volume (cu. ft)	749	1,321	1,827	966	1,555	1,827	819	1,058
Engine type	CFM LEAP-1A PW1124G	CFM LEAP-1A PW1127G	CFM LEAP-1A PW1133G	CFM LEAP-1B	CFM LEAP-1B	CFM LEAP-1B	CS100: PW1519G/ PW1521G CS100ER: PW1524G	CS300: PW1521G CS300XT/CS300ER: PW1524G
Engine thrust (lbs)		CFM - 24,500 to 32,900			20,000 to 28,000		CS100: 18,900 - 21,000 CS100ER: 23,300	CS300: 21,000 CS300XT/CS300ER: 23,300
	PW - 24,000	PW - 27,000	PW - 33,000					
Fan diameter (inches)	78	78	78	69	69	69	73	73
Bypass ratio	CFM - 11:1 PW - 12.5:1	CFM - 11:1 PW - 12.5:1	CFM - 11:1 PW - 12.5:1	9:1	9:1	9:1	12:1	12:1
MTOW (lbs)	STD: 141,100 HGW: 166,450	STD: 154,324 HGW: 174,165	STD: 196,211 HGW: 206,132	159,500	181,200	194,700	CS100: 121,100 CS100ER: 128,200	CS300/CS300XT: 131,300 CS300ER: 139,600
MLW (lbs)	STD: 138,450 HGW: 140,875	STD: 146,166 HGW: 148,592	STD: 170,417 HGW: 174,606				111,500	122,000
MZFW (lbs)	STD: 129,632 HGW: 132,939	STD: 138,450 HGW: 141,757	STD: 161,600 HGW:166,670					
Fuel capacity (USG)	STD: 6,248 HGW: 7,038	STD: 6,248 HGW: 7,038	STD: 6,205 HGW: 7,785					
Range (nm)	4,130	3,700	3,650	3,800	3,620	3,595	CS100 - 2,200 CS100ER - 2,950	CS300/CS300XT: 2,200 CS300ER - 2,950
Cruise speed (Mach)	0.78 - 0.82	0.78 - 0.82	0.78 - 0.82	0.79	0.79	0.79	0.78 - 0.82	0.78 - 0.82
On-board MTCE computer	Yes*	Yes*	Yes*	Yes*	Yes*	Yes*	Yes	Yes
EFB	Yes*	Yes*	Yes*	Yes*	Yes*	Yes*	Yes	Yes
ETL	Yes*	Yes*	Yes*	Yes*	Yes*	Yes*	Yes	Yes
Fuel burn savings**	15%	15%	15%	13%	13%	13%	20%	20%
NOx margin to CAEP VI	50%	50%	50%	50%	50%	50%	50%	50%
Noise margin to Stage IV (EPNdB)	15	15	15	10 - 15%	10 - 15%	10 - 15%	21	20
CO2 savings (tonnes per year)	3,600 per a/c	3,600 per a/c	3,600 per a/c	3,050 per a/c	3,050 per a/c	3,050 per a/c	20%	20%
Entry into service	2015	2015	2015	2017	2017	2017	2013	2013
Orders		1,459 for entire A320neo family			649 for entire 737 MAX family		66	72

Key:
STD = Standard weight variant
HGW - Higher gross weight variant
a/c = aircraft
* = Anticipated
** - Fuel burn savings compared to current generation same-sized aircraft

that is 540nm longer than the 737-900ER at 3,595nm *(see table, this page)*.

Unlike the A320neo, there will be no engine choice for the 737 MAX family. As with the two previous 737 families, the CFMI will have a monopoly on the 737 MAX.

The CFM LEAP-1B engines will have very similar thrust ratings to the current CFM56-7B product line, and will be rated at 20,000–28,000lbs of thrust *(see table, this page)*.

Similarly to Airbus, Boeing's philosophy for the 737 MAX has been to keep changes to a minimum from the current 737NG family. The new engine type will be the largest change, with several other changes needed to the aircraft to accommodate the new engines.

Since the CFM LEAP-1B engines will have a larger fan diameter of 69 inches *(see table, this page)*, compared to 61 inches for the CFM56-7B, an eight-inch nose-gear extension is required to maintain the same engine ground clearance for the 737 MAX as on the 737NG family.

The main landing gear will also be strengthened to accommodate the higher take-off weights achieved. Minor changes to the wing and fuselage will also be carried out to carry the increased loads by the larger engines.

The A320neo's main improvement over the A320 family is the utilisation of a new high bypass engines that will deliver a fuel burn reduction of about 15%. The A320neo will have few other changes compared to the A320.

The 737 MAX will also feature new winglets. Many 737NG aircraft have been retrofitted with eight-feet-high blended winglets, following delivery. The majority of new deliveries over the past five years have had blended winglets installed as standard, however.

The winglet on the 737 MAX family has been designated the 737 MAX advanced technology (AT) winglet, and features two sections: the larger section, pointing upwards, will be more than eight feet high; while the smaller, bottom section, faces diagonally downwards and will be more than four feet long.

Boeing says that the 737 MAX AT winglet will create a 1.5% reduction in fuel use compared to the current generation, blended winglets on the 737NG.

The 737 MAX will also incorporate certain flight control and system updates. For example, the flight controls will include fly-by-wire spoilers, which replace the mechanical system on the 737NG.

An electronic bleed air system will be introduced on the 737 MAX to increase optimisation of cabin pressurisation, aiding passenger comfort. Boeing states that it is still conducting aerodynamic studies to further optimise the design of the 737 MAX, before the final specifications are released in mid-2013.

In terms of fuel efficiency, Boeing states the 737 MAX will reduce both fuel burn and CO2 emissions by 13% compared to the most fuel-efficient current generation narrowbodies *(see table, page 30)*.

Boeing says that when a fleet of 100 737 MAXs is compared with 100 current generation narrowbodies, the 737 MAX will emit 305,000 fewer tons of CO2 and save 30 million USG of fuel per year. This translates into a cost saving of more than $100 million; equal to about $1 million per aircraft.

Boeing also claims the 737 MAX's fuel burn will be 8% lower per-seat than the competition, based on a 737 MAX 8 operating a 500nm US domestic route in two-class configuration and fuel prices at $3.50 per gallon. Boeing also says that this will translate into an 8% per-seat advantage over the A320neo in terms of overall operating costs.

Environmentally, the 737 MAX will reduce the operational noise footprint by 40% compared to current generation aircraft, and will have a 10–15% margin over Stage IV noise regulations *(see table, page 30)*.

NOx emissions will be about 50% below CAEP VI limits *(see table, page 30)*, which is directly comparable with both the A320neo and CSeries.

Five years before entry into service, the 737 MAX has 649 firm orders *(see table, page 30)*. Customers have not yet specified which variants will be delivered. The orders are from Lion Air (201 aircraft), Southwest (150), Norwegian Air Shuttle (100), United Airlines (100), Air Lease Corporation (75) and Virgin Australia (23).

CSeries

Bombardier originally announced the CSeries programme in 2004, with its first flight due for December 2012 and entry into service due at the end of 2013.

The CSeries is designed specifically for the 100–145-seat category, and comprises two main sub-variants.

The shorter CS100 will seat 100 passengers in a dual-class configuration, 110 passengers in a standard single-class configuration, and up to 125 passengers in a dense layout *(see table, page 30)*.

The longer CS300 will seat 120 passengers in a two-class layout, 130 in a standard one-class layout, and a maximum of 145 in a dense one-class layout *(see table, page 30)*.

Both variants will have a 2-plus-3-seats-abreast layout in economy class.

Two variants of the CS100 will be offered: the CS100 and the CS100ER. The MTOW of the CS100 will be 121,100lbs, with the CS100ER at 128,200lbs *(see table, page 30)*.

Maximum payload will be 32,100lbs for both variants, including cargo weight of 8,190lbs, in a cargo volume of 819 cubic feet *(see table, page 30)*.

The maximum range for the CS100 will be 2,200nm, with the CS100ER having a longer range of 2,950nm *(see table, page 30)*.

The larger CS300 will be offered in three variants. These are the CS300, the CS300XT (extra thrust), and the CS300ER. The standard CS300 and CS300XT will have a MTOW of 131,300lbs, while the CS300ER will have a MTOW of 139,600lbs *(see table, page 30)*. The CS300 variants will have a maximum payload of 38,200lbs. Available cargo volume is 1,058 cubic feet, allowing for a potential cargo weight of 10,580lbs.

The CS300 and CS300XT will have a maximum range of 2,200nm, while the CS300ER will have a maximum range of 2,950nm *(see table, page 30)*.

As with the 737 MAX, the CSeries will have no engine choice. The PW1000G family of engines, and in particular, the PW1500G, will power all variants and sub-variants of the CSeries.

The CS100 will be powered by either the PW1519G, with a thrust rating of 18,900lbs, or the PW1521G, rated at 21,000lbs of thrust *(see table, page 30)*.

The PW1521G will also power the CS300. The CS100ER will be powered by the PW1524G, which has a thrust rating of 23,300lbs *(see table, page 30)*. This higher thrust-rated PW1524G engine will also power the CS300XT and CS300ER.

Since the CSeries is a completely new aircraft design, it includes several new technologies to help reduce weight and fuel burn, and so contribute to lowering operating and maintenance costs.

The fuselage, for example, will

The CSeries will use the ultra high bypass PW1500G. This will give the two CSeries models a fuel burn advantage of about 20% over similar-sized current generation aircraft.

comprise 70% composite materials, made up of 46% advanced lightweight composite, and 24% aluminium lithium. Composite materials will also be used throughout the wing structure. Bombardier says half the aircraft's weight is carbon fibre.

Another new technology is electric brakes in the main landing gear. Electric brakes have a maintenance cost benefit for CSeries operators because there will be no hydraulic leakages, which are seen on current generation aircraft. Additionally, brake wear can be measured from the flightdeck.

The aircraft has been designed to be corrosion-resistant. This is achieved through the use of coatings and composite materials throughout the structure of the aircraft.

Several features have been included to give the aircraft high field performance. One is a high aspect ratio, long wingspan. Overall, the aircraft should have the longest range combined with the shortest field performance.

Bombardier says that on a 500nm sector, the CSeries will have a 20% fuel burn advantage over similar-sized current generation in-production aircraft *(see table, page 30)*. These include the E-195, 737-600 and A318 in the case of the CS100, and the 737-700 and A319 in the case of the CS300.

It also says the CSeries will achieve a 50% fuel burn advantage over out-of-production aircraft in the same size class.

This will be achieved through new technologies and materials on the aircraft. The CS100 is about 12,000lbs lighter than the A319, and the CS300 is about 20,000lbs lighter than the A320.

The CSeries will also take advantage of the new ultra high bypass engine, the PW1500G. The PW1500G powering the CSeries will have a bypass ratio of about 12:1. This compares to engine bypass ratios of 10:1 for the A320neo family and 7-8:1 for the 737 MAX family. These lower bypass ratios are explained by the aircraft having lower ground clearance.

In terms of overall economics, Bombardier claims that the CSeries will have 15% lower cash operating costs compared to in-production aircraft of similar size. This is based on the North American environment on an average 500nm sector. Bombardier says the CSeries will achieve a 30% cash operating cost advantage over similarly sized aircraft that are out-of-production.

The CSeries also looks set to reduce the environmental footprint compared to current generation aircraft. The aircraft will have NOx emissions that are more than 50% below CAEP VI requirements, and produce 20% less CO2 emissions than current in-production aircraft *(see table, page 30)*.

The noise footprint of the CSeries will also be four times quieter than a comparable in-production aircraft. This is 20–21 EPNdB below Stage IV noise regulations *(see table, page 30)*.

Currently, the CSeries has attracted 138 firm orders *(see table, page 30)*. The largest orders are from Republic Airways (40 aircraft – all CS300s), Swiss European Airlines (30 – all CS100s).

PW1000G

The PW1000G family of engines will not only be used to power the A320neo family and the CSeries, but also the Irkut MC-21 and the Mitsubishi Regional Jet (MRJ).

The PW1100G series will power the A320neo family, the PW1200G series will power the MRJ, the PW1400G series will power the MC-21, and the PW1500G will power the CSeries.

Focusing on the A320neo and CSeries, the PW1100G engines powering the A320neo family will have a fan diameter of 81 inches, and will be the largest of the PW1000G family of engines. This will provide it with a bypass ratio of 12.5:1.

The fan diameter of the PW1500G, powering the CSeries will be 73 inches *(see table, page 30)*. This will give it a bypass ratio of 12:1 (*see table, page 30)*.

The PW1000G family of engines looks set to provide significant fuel consumption reductions when compared with current generation aircraft. PW says that the PW1000G family will provide annual fuel savings of 15% on the aircraft it will power when compared to current generation narrowbodies. This is about 370,000USG of fuel per aircraft per year, which represents annual savings of $1.1-1.2 million per aircraft at current fuel prices.

The PW1000G will also offer significant environmental reductions. Emissions of CO2 will be about 15% lower than today's best engines; in proportion with the PW1000G's lower fuel burn. This will amount to a reduction of 3,000 tonnes of CO2 per aircraft per aircraft.

NOx emissions will also be 50% lower than CAEP VI margins for both the A320neo and the CSeries *(see table, page 30)*.

PW also anticipates that the PW1000G family of engines will create a 75% smaller noise footprint than current generation engines. In terms of noise reduction, the engines will have noise emissions 15–20EPNdB lower than Stage IV regulations.

These efficiencies and reductions are created by a variety of changes, updates, and new technologies. The biggest contributors are a higher bypass ratio and overall pressure ratio.

The PW1000G engine family uses geared turbofan technology. This is an advanced gear system allowing the engine's fan to operate at a different revolutionary speed (RPM) to the low-pressure compressor (LPC). The geared turbofan technology uses a speed reduction gearbox between the engine's

The CSeries has taken advantage of lightweight materials. This makes the CS100 about 12,000lbs lighter than the A319, and the CS300 about 20% lighter than the A320.

low-pressure turbine (LPT) and fan. That is, the LPT powers both the LPC and the fan, but the reduction gearbox allows the fan and LPC to turn at different RPMs.

This engine architecture allows the engine's LPT and LPC to operate at higher rotational speeds for peak efficiency, while at the same time the engine's fan operates at lower speeds to optimise overall configuration.

This allows a wider fan diameter, and results in fewer parts and components. The wider fan diameter increases airflow and bypass ratio and improves propulsive efficiency, and also reduces noise levels. Higher propulsive efficiency translates into lower fuel burn.

The LPC's and LPT's higher speeds increase their efficiency and do the same amount of work (increasing pressure) with fewer stages than a conventional two-shaft engine. Fewer stages, and so airfoils, contribute to lower maintenance costs.

CFM LEAP-1 family

The CFM LEAP-1 engine will be used to power the A320neo (designated LEAP-1A), the 737 MAX (LEAP-1B), and the COMAC C919 (LEAP-1C).

The LEAP-1A will be the first engine in service with the A320neo, and will have a fan diameter of 78 inches and a bypass ratio of 11:1 *(see table, page 30)*. This will be achieved through the use of a higher core pressure ratio and higher combustion temperature, and a smaller diameter core.

The LEAP-1B will enter service later on the 737 MAX, and will have a fan diameter of 69 inches, with a smaller bypass ratio of 9:1 *(see table, page 30)*.

CFMI says that the LEAP-1 family of engines will provide up to 15% lower fuel consumption in comparison with current generation CFM56 engines: the -5B and -7B.

The LEAP-1's NOx emissions will be 50% below CAEP VI margins (the same as the PW1000 family), with noise emissions 1–15% below Stage IV regulations.

CFMI is aiming to maintain the same maintenance costs and reliability of the current CFM56 family on the CFM LEAP-1 engine family. This is because CFMI claims that the CFM56's maintenance costs are already 20% lower than the competition. This is in addition to providing 15% lower fuel burn than current generation engines.

First, the CFM LEAP-1 will have fewer fan blades than the CFM56 family, utilising 18 wide chord, swept blades instead of the CFM56-7B's 24, and the -5B's 36.

New technology used in the CFM LEAP engines includes carbon fibre composites being used in these fan blades and the fan case. Fan blade materials reduce fan weight by about 1,000lbs per aircraft.

Second, the CFM LEAP-1 family of engines incorporates a new foreign object debris (FOD) rejection system, first used on the GE90, using a variable bleed valve (VBV). The VBV removes small particles of FOD, such as sand, before it can enter the engine core.

The LEAP-1 family will also use a lean burn combustor, which helps to keep engine temperature more uniform and therefore reduce local hot spots of extreme high temperatures that occur more frequently in older engine types.

This helps maintain high pressure turbine (HPT) durability.

The LEAP-1 family will also incorporate use of ceramic coatings in the HPT blades. This material has a higher temperature capability than metals, so wear and tear on these components can be reduced.

A multitude of new diagnostic sensors will also be incorporated into the CFM LEAP engines. These will use multiple data sources and channels for engine health monitoring (EHM) to pinpoint exactly where faults may be occurring. These can be transmitted to the ground via the aircraft communications addressing and reporting system (ACARS).

Maintenance programme

Incorporating new engines, new materials and new technologies to an aircraft should improve durability and reliability. These, and other factors, will contribute to reducing maintenance costs by extending intervals between maintenance checks.

Bombardier's CSeries is a prime example. A check tasks for the CSeries will have an interval of 750FH at service entry, while C checks will have an initial interval of 7,500FH. Heavy structural inspections will have a 12-year interval. The CSeries is the only narrowbody to have a 12-year interval for its structural inspection at service entry.

These intervals are directly comparable to those seen on the A320neo and the 737 MAX, and are improvements over current generation aircraft.

Bombardier states it has combined new technology with as much system integration as possible to reduce the number of rotable components on the aircraft. The CSeries will also incorporate easy access panels to improve access to rotable components, and make routine inspections easier.

Enhanced diagnostics, or aircraft health monitoring (AHM) will also be a key feature of the CSeries maintenance programmes. Diagnostics of all systems will be centrally reported, with a parameter snapshot on any faults. This will aid maintenance controllers and mechanics in solving any problems as quickly as possible. The CSeries' AHM system is designed to anticipate unscheduled maintenance events. CSeries

Few details have been disclosed about the 737 MAX family. One feature is that the C check intervals will be 36 months, 15,000FH and 6,600FC. This is 24 months, 7,500FH and 1,600FC longer than the A320's current C check intervals.

operators will also have the option to use Bombardier to analyse AHM data to monitor component parameters.

The CSeries has also been designed to support the use of electronic flight bags (EFBs) and electronic technical logs (ETLs), which will be part of the AHM system.

Since airlines must have the correct processes in place in their own systems to make use of ETLs and EFBs, they will be optional.

Operators will also have the choice of receiving technical publications in electronic format. This gives airlines the ability to access manuals through laptops, tablet computers, and the on-board maintenance computer. The on-board maintenance computer on the CSeries can be accessed through the main flightdeck display, as well as various points on the aircraft. This is similar to the A380.

Airbus states that the commonality between the current A320 family and the A320neo is the main driver in the development of the A320neo. This is extended to include maintenance procedures. For example, the intervals between maintenance checks will remain common between the A320neo and improved maintenance programme for the current A320.

The A320's base check intervals were recently escalated to 7,500FH, 5,000FC and 24 months.

Typical A-check tasks will have an interval of 750 flight hours (FH), 750 flight cycles (FC), or 120 days.

By using the most appropriate usage parameters when choosing the task interval, Airbus says that gives operators maximum flexibility to package the tasks in the most effective way for them, according to their own aircraft utilisation or maintenance policy.

Airbus aims to extend these A-check intervals even further to 1,500FH, 1,500FC, or 180 days, during the design phase of the A320neo; although these are yet to be confirmed.

The intervals for typical C-check tasks for the A320neo will be 7,500FH, 5,000FC, or 24 months. The heavy maintenance checks will be done after six and 12 years of service. As with a recent change to the A320's maintenance programme, the A320neo's base maintenance will be based on a cycle of six base checks, with the third and sixth checks being heavy checks that include structural inspections.

Airbus will be incorporating changes to reduce maintenance costs on the A320neo. For example, the A320neo will include the application of A380 bleed valve technology. This will consist of electrically-operated, rather than pneumatically-operated, valves, which reduces the maintenance costs on these components by 70%.

The A320neo will also feature improved landing gear, compared to the current A320. This will have an overhaul interval of 12 years, rather than 10 years for current A320 models.

Other changes under development by Airbus include a new auxiliary power unit (APU), and an improved fuel system. Airbus states these changes will have higher reliability and lower maintenance costs than the equivalent systems on the current A320 family.

Boeing will be extending scheduled maintenance intervals for the current 737NG family, and plans to offer the same improved programme for the 737 MAX. The objective is to reduce aircraft downtime and overall maintenance costs.

The 737 MAX's improved maintenance programme will have an A-check interval of 120 days, which is the same as that offered on the A320neo.

C checks will have intervals of 36 months, 15,000FH, or 6,600FC. This is a longer interval than offered on the A320neo and the CSeries.

The 737 MAX's heavy maintenance, D-checks, will be carried out every nine and 12 years of service. This programme will be in place by 2014 for the 737NG family, and will continue for the 737 MAX family.

Boeing states these improvements will be in place to maintain 99.7% dispatch reliability for both the 737NG and 737 MAX, and to achieve 20–30% lower maintenance costs than its competitors.

Since the A320neo and 737 MAX are still a number of years away from entry into service, details of the use of EFBs, ETLs, and on-board maintenance computers for the A320neo and 737 MAX have not been finalised. It is, however, anticipated that both Boeing and Airbus will make full use of the technology available to use EFBs and ETLs in the A320neo's and 737 MAX's maintenance procedures.

Summary

While the traditional targets of lower fuel burn continued to be followed in the next generation of aircraft, other elements of operating cost are also being pursued with the A320neo, 737 MAX and CSeries. Many of these relate to maintenance costs.

While manufacturers continue the quest to further streamline maintenance programmes, other elements of maintenance cost are also being targeted to effect reductions in the overall cost of maintenance. This includes using on-board maintenance computers and ETLs to reduce both direct maintenance inputs and lower the associated overhead of maintenance. Further features relating to these challenges will be revealed for the A320neo, 737 MAX and CSeries. AC