Boeing, Airbus, Embraer and Bombardier will introduce new 100- to 150-seat aircraft over the next few years. The potential for direct competition between new and existing aircraft in this market is examined here. Fuel burn and maintenance cost reductions are considered for the new types.

100-150 seat aircraft: EJets-E2 & CSeries versus 737 MAX 7 and A319neo

For many years the 100-150-seat aircraft category was dominated by Boeing and Airbus, with the 737 and A320 families.

Before the end of this decade Boeing, Airbus, Embraer and Bombardier will introduce new types into this market segment. Boeing, Airbus and Embraer have decided to offer modified versions of their current products, while Bombardier will deliver a clean-sheet narrowbody design in the form of its CSeries family.

The extent to which current and future aircraft in the 100-150-seat category might directly compete is assessed here. Operating cost reductions relating to fuel burn and maintenance are considered for the new types.

In-service aircraft

The main in-production, in-service aircraft in the 100-150-seat category are the 737-700, A319, E190, E195 and CRJ1000. In total there are about 3,000 active aircraft in passenger configuration.

Boeing and Airbus' smallest narrowbody variants, the 737-600 and A318 are not considered here. They were only produced in small numbers and neither manufacturer will include re-engined variants in their 737 MAX and A320neo (new engine option) families.

The 737-700's, A319's, E190's, E195's and CRJ1000's characteristics are summarised *(see table, page 19)*.

The 737-700 and A319 represent the majority of the active fleet in the 100-150-seat category, and offer the largest capacity and longest range.

The E190, E195 and CRJ1000 cannot directly compete with the Boeing and Airbus products from a capacity and range perspective.

The CRJ1000 is essentially a large regional jet (RJ). It is unlikely to be considered as a direct alternative to 737-700s or A319s.

The E190 and E195 offer staggered capacity increases between the 70-90-seat RJs and the smaller members of the 737 and A320 families. The E190 and E195 may be used by 737-700 or A319 operators for 'right-sizing' on developing routes, or on those with thinner demand. Right-sizing is where aircraft capacity is matched more closely to demand.

New aircraft

Over the next five years a number of new 100-150-seat aircraft will enter service, including the 737 MAX 7, A319neo, E190-E2 and E195-E2, and Bombardier's CSeries featuring the CS100 and CS300.

The 737 MAX, A320neo and E-Jets E2 programmes all involve modifying existing aircraft to improve cash operating costs. The biggest change is the incorporation of new engine technology. There are some improvements in airframe-related maintenance.

However, Bombardier is the only manufacturer introducing new clean-sheet design aircraft in this size category. This should provide larger improvements in airframe maintenance requirements and costs as normally associated with a new technology aircraft.

737 MAX 7

The 737 MAX 7 is the smallest of three members of Boeing's new 737 MAX family. The 737 MAX 7 is a direct replacement for the 737-700. The MAX 7 will therefore have a standard two-class capacity of 126 *(see table, page 20)*.

The MAX 7's main feature is a new engine, the CFMI LEAP 1-B. The aircraft will also feature advanced technology (AT) winglets as standard.

The MAX 7's characteristics are summarised *(see table, page 20)*. The type is due to enter service in 2019.

A319neo

The A319neo will be the smallest member of Airbus's A320neo family that will replace the current A320 family and also include the A320neo and A321neo. Original A320 family aircraft are now referred to as CEOs (classic engine options).

The A319neo is a direct replacement for the original A319. The two feature the same seating configurations *(see table, this page & page 19)*.

The main difference between the original A319 and the A319neo is the latter's new engine options. A319neo operators will have a choice between CFMI LEAP 1-A and PW1100G engines. The highest thrust rating will be 27,000lbs for both engine variants.

The A310neo is due to enter service in 2016.

E190-E2 and E195-E2

The E190-E2 and E195-E2 are the largest members of Embraer's E-Jets E2 family. The E190-E2 will therefore have a 114 high-density seat capacity *(see table, page 20)*.

The fuselage of the E195-E2, however, will be longer than the original E195. The E195-E2 will therefore have a higher seat capacity of 118 in a dual-class cabin, and 144 in a high-density one.

The E190-E2 and E195-E2 will be powered by the PW1900G engine series.

There are 50 E190-E2s and 50 E195-E2s on order, and the first aircraft are due to enter service in 2018 and 2019.

CS100 and CS300

Bombardier's CSeries is the only all-new aircraft family in the 100-150-seat category. It comprises the CS100 and CS300.

The CS100 and CS300 will have an

IN-SERVICE 100-140-SEAT AIRCRAFT SPECIFICATIONS

	737-700	A319	E190	E195	CRJ1000
Two Class Seating	126	124	97	106	93
Std Single Class Seating	140	134	106	118	100
Max High Density Seating	149	156	114	124	104
Economy Layout	3+3	3+3	2+2	2+2	2+2
Cargo volume (cu ft)	966	976	799	906	683
Engine Type	CFM56-7B	CFM56-5B/V2500-A5	CF34-10E	CF34-10E	CF34-8C5A1
Engine Thrust (lbs)	up to 26,300	up to 27,000/26,600	STD: 16,650 HIGH: 18,500	STD: 16,650 HIGH: 18,500	13,680-14,510
Fan Diameter (inches)	61	68.3/63.5	53	53	52
Bypass Ratio	5.1-5.5:1	5.7-6.0:1/4.8-4.9:1	5.4:1	5.4:1	5:1
MTOW (lbs)	133,000-154,500	136,686-168,653	STD: 105,359 LR: 110,893 AR: 114,199	STD: 107,564 LR: 111,973 AR: 115,280	EL: 85,968 STD: 90,000 ER: 91,800
MZFW (lbs)	120,500-121,700	114,640-128,970	STD/LR: 89,949 AR: 90,169	STD/LR: 93,696 AR: 93,917	77,500
OEW (lbs)	83,000	-	STD/LR: 61,112 AR: 61,333	STD/LR: 62,942 AR: 63,162	51,120
Payload (lbs)	37,500-38,700	-	28,836	30,754	26,380
Range (nm)	3,445 (with winglets)	3,700 (with Sharklets)	STD: 1,800 LR: 2,300 AR: 2,400	STD: 1,500 LR: 1,900 AR: 2,200	EL: 971 STD: 1,425 ER: 1,622
Cruise Speed (Mach)	0.78	0.78	0.78	0.78	0.78
In service	1,050	1,297	482	126	37
Firm order backlog	133	65	67	13	33

Notes:
Range based on:
1). Max pax payload - dual class configuration for 737-700 & A319 - std single class configuration for E190/195 & CRJ1000
2). In-service and order backlog numbers correct as of May 2014.

economy layout of five-abreast seating. The CS100 will have 108 seats in a dual-class cabin, or up to 125 passengers in a high-density one *(see table, page 20)*.

The larger CS300 will accommodate 130 passengers in a dual-class layout, and up to 160 in a high-density cabin.

Both CSeries aircraft will be powered by the PW1500G series of engines.

In a standard configuration the base weight variants of the CS100 and CS300 will both have a range of up to 1,500nm.

As of May 2014 there were 63 CS100s and 138 CS300s on order, representing the largest order backlogs of any of the new 100- to 150-seat aircraft types. The first CS100 and CS300 are due to enter service in 2015 and 2016.

Operating efficiencies

The 737 MAX, A320neo, E-Jets E2 and CSeries families have all been designed to offer lower operating costs than comparable in-service aircraft.

Two key operating cost considerations are fuel burn and maintenance. The extent to which new aircraft in the 100-150-seat category may reduce these costs is considered here.

Fuel burn

Fuel has become the largest single operating cost for airlines. Rising oil prices have driven demand for more fuel-efficient aircraft.

Boeing estimates that the 737 MAX 7 will deliver 13% on-wing fuel savings compared to current production 737-700s. This is based on a fuel cost-per-seat comparison for a dual-class cabin. "We have already reduced the fuel burn of the 737NG family by 6% since it was first introduced," claims Darren Hulst, director of product forecast at Boeing Commercial Airplanes.

For the A319neo, Airbus is targeting a fuel burn reduction of 15% compared to an A319ceo without Sharklets.

Embraer claims that the E190-E2 will offer a 16% reduction in fuel burn per seat compared to the original E190. Embraer is targeting a 24% reduction in fuel burn per seat for the E195-E2 compared to the original E195.

"The E195-E2 will burn 15% less fuel per trip and 10% less per seat compared to the re-engined A319neo and 737 MAX 7," claims Paulo Cesar Silva, president and chief executive officer at Embraer Commercial Aviation. "The E190-E2 will offer a 20% reduction in fuel burn per trip compared to the A319neo and 737 MAX 7."

Bombardier claims that the CS100 and CS300 will burn 20% less fuel per seat than similar size, in-service aircraft. The CS100 would therefore be expected to burn 20% less fuel than a 737-600 or A318, while the CS300 would use 20% less than an A319 or 737-700.

Bombardier believes the CSeries will burn 50% less fuel than older aircraft, such as the MD-80. It expects the CS100 and CS300 to maintain a fuel burn per seat advantage of at least 10% over their respective re-engined, 737 and A320neo family competitors.

All of the new 100-150-seat aircraft will demonstrate lower fuel burn than current-generation, in-service types.

Fuel burn comparison

Aircraft Commerce has estimated the potential fuel burn performance of the 737 MAX 7, A319neo, E190-E2, E195-E2, CS100 and CS300, based on the expected and approximated efficiency improvements. The estimates assume that all aircraft are operating with a full passenger payload in a dual-class cabin configuration.

For a typical route of a tracked distance of 600nm, this analysis suggests that the E190-E-2 would have the smallest block fuel burns, followed closely by the E195-E2 and the CS100, each with similar fuel consumption. The E195-E2, however, has about an eight-seat higher capacity than the CS100.

The CS300 would have the fourth-highest trip fuel burn. This would be close, but about 5% lower than the A319neo. The 737 MAX 7 is estimated to have the highest trip fuel burn at this stage, which is about 18% higher than

NEW 100-140-SEAT AIRCRAFT SPECIFICATIONS

	737 MAX 7	A319neo	E190-E2	E195-E2	CS100	CS300
Two Class Seating	126	124	97	118	108	130
Std Single Class Seating	140	134	106	132	110	135
Max High Density Seating	149	156	114	144	125	160
Economy Layout	3+3	3+3	2+2	2+2	2+3	2+3
Cargo Volume (cu ft)	954	976	752	1,038	838	1,116
Engine Type	CFMI LEAP-1B	CFMI LEAP-1A/PW1100G	PW1900G	PW1900G	PW1500G	PW1500G
Engine Thrust (lbs)	-	up to 27,000-	STD Thrust: 19,000	STD Thrust: 21,000	18,900-23,300	21,000-23,300
	-	-	High Thrust: 22,000	High Thrust: 22,000		
Fan Diameter (inches)	69	78/81	73	73	73	73
Bypass Ratio	9:1	11:1/12:1	12:1	12:1	12:1	12:1
MTOW (lbs)	159,500	141,096-166,449	125,443	130,954	Base: 116,000	Base: 129,000
					Max: 129,000	Max: 144,000
Payload (lbs)	-	-	28,836	33,400	Base: 30,150	Base: 35,900
					Max: 32,150	Max: 40,900
Range (nm)	3,850	4,200	2,800	2,000	Base: 1,500	Base: 1,500
					Max: 2,950	Max: 2,950
Cruise Speed (Mach)	0.78	0.78	0.78	0.78	0.78	0.78
Fuel Burn Savings (% per seat)	13%	15%	16%	24%	20%	20%
Entry into Service	2019	2016	2018	2019	2015	2016
Firm Order backlog	57	27	50	50	63	138

Notes:
1). 737 MAX 7- range/fuel burn based on max pax payload in dual class configuration. Fuel savings based on comparison with 737-700.
2). A319neo -range/fuel burn based on max pax payload in dual class configuration. Fuel savings based on comparison with an A319ceo without Sharklets.
3). E190/195-E2 - range/fuel burn based on max pax payload in std single-class configuration. Fuel savings based on comparison with E190/195.
4). C100/300 --range/fuel burn based on max pax payload in std single-class configuration. Fuel savings based on comparison with similar size in-service aircraft.
5). Any stated OEWs are estimates only - OEW will vary by individual aircraft.
6). Order backlog correct as of May 2014.

the A319neo.

At current spot fuel prices of $3.00 per US gallon, the CS300 would have the lowest fuel burn per seat, and so the lowest cost per available-seat-mile (ASM). It is estimated that the CS300's cost per ASM would be 3.44 cents. The E195-E2 and A319neo would have the next lowest costs at 3.65 and 3.83 cents per ASM respectively.

The CS100 would be slightly higher per seat at 3.98 cents. The smallest E190-E2 would, perhaps not surprisingly, have one of the highest costs per seat of 4.35 cents per ASM, because it has fewer seats than the other five types.

The heavy 737 MAX 7, however, is estimated here to have the highest cost of 4.44 cents per ASM. This is because the 737-700/737 MAX 7 are inherently less fuel-efficient than their A319/A319neo counterparts.

This analysis is a rough guide only and should be treated with caution as a number of assumptions were necessary.

The estimated performance was calculated by subtracting the expected percentage reductions in fuel burn from figures for comparable in-service aircraft. The figures for these in-service aircraft were taken from previous Aircraft Commerce aircraft guides.

The fuel burn for the 737 MAX 7 was subtracted from that for the 737-700, the A319neo from the A319, the E190-E2 and E195-E2 from the E190 and E195, and the CS100 and CS300 from the A318 and A319 respectively.

Embraer and Bombardier both state that the fuel burn improvements expected with the E-Jets E2 and CSeries are based on the aircraft operating with a full, single-class passenger load. This analysis assumes that they would demonstrate similar reductions with a full dual-class passenger load, with aircraft configured in a typical US layout.

The analysis also makes several assumptions about the performance of the in-service aircraft. The fuel-burn figures for these aircraft were previously calculated for routes of varying length. They have been manipulated to create estimated fuel-burn numbers for a theoretical route of 600nm. Unlike the original flight plan data, this approach does not take account of variables, such as wind, temperature or air traffic control (ATC) restrictions, holding altitudes, and diversion or alternate airport distances.

It should also be noted that the fuel-burn figures used for the in-service aircraft were based on certain weight variants with specific engine models. The fuel burn could vary with different weight or engine options.

Engines

New engine technology is one of the main contributing factors to the fuel-burn improvements promised by the 737 MAX, A320neo, EJets-E2 and CSeries families.

The operating efficiency of engines, and therefore an aircraft's fuel burn performance, is influenced by thermal and propulsive efficiency.

Thermal efficiency is determined by how efficiently the energy from hot expanding gases, resulting from fuel combustion, is converted into mechanical energy in the engine's core.

Propulsive efficiency is improved when the exit speed of the engine's exhaust gases are closer to the aircraft's forward speed. Accelerating a larger mass of air by a small amount will lead to a higher propulsive efficiency than accelerating a smaller mass of air by a larger amount. Propulsive efficiency is improved by increasing the engine's bypass ratio. This is the total amount of air passing through the intake fan compared to that passing through the core.

The bypass ratio of an engine can be increased by either increasing the size of the fan or reducing the size of the core.

The new aircraft in the 100-150-seat category will be powered by the Pratt & Whitney (PW) PurePower PW1000G or CFMI LEAP-X engine families. Only the A319neo will offer a choice between the two engine manufacturers.

Maintenance

With each new aircraft programme, manufacturers will look to reduce maintenance costs, through a combination of improved fault diagnostic systems and a reduced number of maintenance planning document (MPD)

The CSeries is the only all-new aircraft programme in the 100-150-seat market. All of the new aircraft in this category are expected to deliver fuel burn and maintenance cost reductions.

tasks, which have longer inspection intervals and lighter and easier access.

Replacing more complex hydraulic or pneumatic mechanical systems with electrical ones is an approach used in new aircraft programmes.

Fly-by-wire (FBW) systems are an example of how the number of maintenance tasks with deep access is reduced. Traditional flight control systems need calibration checks, which involve the removal of cabin items and floor boards. These then have to be reinstalled after the flight controls have been tested and calibrated. FBW controls systems, in contrast, are tested through a software programme from the flightdeck. This uses a fraction of the man-hours (MH) compared to the tests and calibrations for traditional flight controls.

Modern aircraft designs also reduce the parts count and can reduce the number of MPD systems tasks. The use of more composite materials, which are not subject to corrosion, can reduce the number of structural inspection tasks that have longer intervals, and also have lower levels of defects and non-routine rectifications.

Modern aircraft have maintenance steering group 3 (MSG3) maintenance programmes. These allow operators to group maintenance tasks into line and base maintenance checks at intervals that are more appropriate and efficient for their rates of utilisation and overall pattern of operation.

In most cases a number of tasks will have similar intervals that allow them to be grouped into traditional intermediate 'A' checks or base 'C' checks.

Each manufacturer's approach to reducing maintenance costs for their new aircraft is examined here.

Boeing

"Today the 737NG family has a 20-30% maintenance cost advantage over its nearest competition," claims Hulst. "These advantages will translate to the 737 MAX. We are working on improved maintenance programme for the 737NG family that will result in less frequent scheduled maintenance, less airplane downtime and lower overall maintenance costs for both the NG and MAX."

Boeing's target is to extend the 737NG family's current A check interval from 90 to 120 days for both the NG and MAX families, and C check intervals from 30months/ 7,500 flight hours(FH)/ 5,500 flight cycles(FC) to 36months/ 12,000FH/6,600FC.

The interval for major structural inspections is expected to be extended from 8/10/12 years to 9/12 years.

The 737 MAX will have an electronic bleed air system for its ice protection and cabin pressurisation systems. The bleed air system on the current 737NG family is pneumatically controlled.

The current 737NG family has relatively light maintenance requirements, until it reaches the initial threshold of four groups of structural inspection tasks. Many of these require deep access for major structural items.

These include a group with an initial inspection interval of 50,000FC, and a second group with an initial interval of 56,000FC. There are 249 and 212 tasks in these two groups. The tasks include those intended to find damage, wear and cracks. Many are related to the structural integrity of the fuselage and major structural items, such as the horizontal stabiliser, empennage and wings. They need a lot of MH to gain access because they require the removal of interior items.

The problem is further exacerbated by the fact that these deep inspections have relatively short repeat intervals.

There are also two groups of 'flight-length sensitive' (FLS) tasks: FLS1 and FLS2. These are also deep access, structural inspections *(see Assessing the 737NG's base maintenance requirements, Aircraft Commerce October/November 2013, page 40)*. There are 27 and 72 tasks in these two groups. These are likely to come due between 64,000-82,000FH and 42,000-59,000FC, and between 47,000-62,000FH and 33,000-43,000FC.

Aircraft with short average cycles of 1.1FH-1.3FH to 1.0FC could operate up to 2,500-2,800FC per year. These aircraft would be the first to reach the inspection intervals required by the four groups of tasks that total 560 inspections and that would first come due at 14-22 years.

The MH required for these structural inspections will be high, leading to high maintenance costs when they initially come due. The short repeat intervals of a large portion of the tasks means the aircraft's maintenance costs will increase steeply thereafter. These four large groups of structural inspection tasks are likely to represent a possible retirement watershed for many operators.

In some cases alternative means of compliance (AMOC) may be available, but this could lead to higher material costs with the replacement of structural components.

The 737 MAX family would clearly benefit if the equivalent tasks in its maintenance programme are made lighter, have their inspection intervals extended, or altogether eliminated.

The 737 MAX family will feature new connectivity capability. "The MAX will offer airline customers the ability to send real-time data while in the air, which will help operations decisions around maintenance to be made on the ground," adds Hulst. "We are introducing an enhanced on-board network system (ONS) to the 737 platform. This comprises a network file server and enhanced digital flight data acquisition unit. The system will leverage the in-line wireless capability we are bringing to the 737 to support secure communications with the ground-based system."

The current E-Jets are operated by a mix of regional, full-service and low-cost carriers. The E190-E2 and E195-E2 may appeal to a similar range of airlines. JetBlue operates a mixed fleet of E190s and E195s.

Hulst explains that the 737 MAX will have an improved built-in test equipment (BITE) system. "Some fault information on the 737NG is accessed from the forward electronic equipment bay, which takes additional time to access. On the MAX, maintenance technicians will be able to access this data from the flightdeck, speeding up the ability to assess dispatch limitations and perform maintenance actions."

Airbus

"Commonality with the A320ceo family is a main driver in the NEO's development, so there will be no major differences between the CEO and NEO maintenance programmes," explains Arnaud Demeusois, A320 family marketing director at Airbus.

Typical maintenance intervals for the A320ceo family are 750FH/750FC/120 days (whichever comes first) for an A check and 7,500FH/5000FC/24 months for a C check. Airbus says that A320 family operators can now package tasks into a 36-month base maintenance check.

When the A320 family originally entered service, the MPD included a system of eight C checks, with a 15-month interval between each check. The base check cycle included two structural checks (see *A320 family 1st & 2nd base airframe check cost analysis, Aircraft Commerce April/May 2011, page 28*).

This was later revised to allow operators to group tasks according to usage. Many operators still group tasks in traditional A or C check intervals. The interval for the equivalent of a C check was extended to 24 months, and these tasks can now be performed every 36 months. Operators can now build maintenance cycles around six base checks rather than eight. The base check cycle still has two structural checks.

The A320neo family will have the same base maintenance check interval options as the latest CEO aircraft.

Despite this, Demeusois says that the A319neo will offer lower airframe and engine maintenance costs than the A319ceo.

"PW claims that the PW1100G engines will have lower maintenance costs than current engines," says Demeusois. "The A319neo will also see a 5% reduction in airframe maintenance costs."

Some airframe improvements should deliver small reductions in related maintenance costs. The A320neo family will feature a new fuel system with a simpler architecture and fewer pumps, and an improved auxiliary power unit (APU) with longer overhaul intervals.

The A319neo will be a 'full LED aircraft' for both internal and external lighting. LEDs will be more reliable, and need fewer MH than standard lighting.

Improvements to the landing gear on the A320neo family mean that the overhaul interval is extended from 10 to 12 years.

Another improvement in the neo family is electric bleed air valve (EBAS) technology, originally developed for the A380. "This means the bleed air system is controlled by electrically-operated valves, rather than pneumatically-operated units," explains Demeusois. "EBAS technology has been proven to reduce the related maintenance cost by 70%."

Embraer

Embraer's target with the E-Jets E2 is to reduce overall maintenance costs by 15% compared to the current E-Jets. Some of this will be achieved by the new engine technology, but the largest contribution will come from reduced airframe maintenance costs. Embraer expects the cost of scheduled airframe maintenance tasks to be 50% lower per FH on the EJets-E2.

The E-Jets E2 will have longer maintenance intervals than the current E-Jets family.

Current E-Jet operators can group tasks into the equivalent of A and C checks at intervals of 600FH and 6,000FH. "The intervals for the current E-Jets are being escalated to 750FH and 7,500FH," explains Silva. "The intervals for the E-jets E2 are planned to be 850FH and 8,500FH."

Embraer is still developing the MPD for the E-Jets E2, and has yet to confirm if it will contain fewer tasks than that for the current E-Jets. "The main goal is not to reduce the number of tasks, but to reduce costs, such as material and MH requirements," says Silva.

The current E-jets have a central maintenance computer (CMC) with data recording and transmission functions. Operators can perform health monitoring on the ground using Embraer's AHEAD-PRO aircraft health analysis, diagnosis and prognostics system. The E-Jets E2 will have a more advanced CMC with more detailed fault-reporting capability, more memory, a faster fault reporting rate and improved report transmission capabilities.

Bombardier

As the only completely new aircraft programme in the 100-150-seat market, the CSeries will have an all-new maintenance programme. Bombardier expects the CS100 and CS300 to offer a 25% improvement in maintenance costs compared to in-service and in-development aircraft in the same size category.

"At entry into service both CSeries variants will have equivalent A and C check intervals of 850FH and 8,500FH respectively," says Frederic Morais, director of marketing at Bombardier Commercial Aircraft. "The major structural check will be carried out at 12-year intervals. These maintenance

All of the new aircraft types in the 100-150-seat category will use new engine technology. The V2500-A5 and CFM56-5B engine options that power the current A319 will be replaced with the LEAP-1A and PW1100G on the A319neo.

intervals will be further extended based on operational experience."

The use of more corrosion- and fatigue-resistant materials is an important factor in permitting an initial structural check interval of 12 years. Tasks with easier access will help keep the overall MH requirement at a low level.

The CSeries will have fewer mechanical systems than previous aircraft designs. This will result in a lower parts count, fewer inspection tasks and so lower airframe maintenance costs.

"The systems on the CSeries have a high level of integration so fewer tasks need to be performed at each check than for the competition," says Morais.

Examples of new systems in the CSeries include e-brakes, which use electric rather than hydraulic actuators. The CS100 and CS300 will also feature FBW controls.

The CSeries has been designed with maintenance in mind. "We introduced access points that allow most line-replaceable units (LRUs) to be replaced within 20 minutes," claims Morais.

The CSeries will also feature an aircraft health management system (AHMS). This will monitor the health of all of the aircraft's systems and record the data on board to assist with remote troubleshooting and analysis.

"The AHMS will be able to provide live maintenance diagnostics," says Morais. "Operators will be able to use the data for flight operations and planning, or for trend analysis and monitoring for proactive maintenance."

AHMS data will be viewable on multifunction control display units (MCDUs) on the flight deck. CSeries aircraft will have dedicated access points from which technicians can download AHMS data onto portable maintenance devices. There will also be an option to download AHMS data using wireless connectivity.

Market positioning

The benefits of operating different variants from the same aircraft family include maintenance and operational commonality. Airlines will not need to invest in multiple spares inventories or personnel training to operate different size aircraft. Flightcrew and maintenance personnel will only need minimal training to transfer between variants.

The E190-E2 and E195-E2, and the CS100 and CS300, will also benefit from the family commonality concept. The difference is that they are optimised for slightly lower capacity segments than the 737 MAX and A320neo families.

Embraer believes its E-Jets E2 could complement larger narrowbodies. "The E195-E2 is designed to be larger than the current E195, but slightly smaller than the A319neo and the 737 MAX 7, while offering a lower cost per seat and significantly lower cost per trip," explains Silva. "This means that they could complement larger narrowbodies by giving airlines lower risk opportunities for developing new markets."

Bombardier sees the CSeries as a potential complement to the 737 and A320 families. "The CSeries is designed specifically for the 100-149-seat segment," says Morais. "It is optimised for this segment, while the 737 and A320 families are optimised for the segment above."

737 and A320 family aircraft are most likely to be operated by full-service and low-cost carriers (LCCs).

The E-Jets E2 and CSeries are likely to appeal to regional and full-service carriers, but may also be used by LCCs. Currently 48% of E-Jets operators are regional carriers, 32% are full-service airlines and 20% are LCCs. JetBlue is an LCC that uses E-jets on thinner demand routes alongside its fleet of A320s.

Bombardier also believes that the CSeries could appeal to LCCs. "I think we will see the LCC model evolving from fleets focused on one type such as 737s or A320s, to one that also includes smaller aircraft like the CSeries," says Morais.

Summary

The 737-700 and A319 dominate the in-service fleet of 100-150-seat aircraft. The E190, E195 and CRJ1000 cannot directly compete with the Boeing and Airbus products on a capacity and range basis. The CRJ1000 is more suited to regional airline applications, while the E190 and E195 may be an option for narrowbody operators on thinner demand routes or new markets.

All of the new 100-150-seat aircraft are targeting fuel and maintenance cost reductions over the comparable in-service fleet.

New engines will be among the largest contributory factors to improved fuel burn performance. They will also contribute to reduced maintenance costs.

Longer intervals between MPD inspection tasks, easier access, and lower non-routine ratios will all contribute to reducing maintenance costs on the new aircraft. The replacement of mechanical systems with electrical equivalents and the use of more corrosion- and fatigue-resistant materials are some of the approaches used to reduce the number of tasks and increase task intervals.

Boeing and Airbus face more direct competition in the new aircraft category. The CS300 can match the capacity of the 737 MAX 7 and A319neo, and may be considered as a direct alternative.

The CS100, E190-E2 and E195-E2 are potentially more suited to regional applications, or for right-sizing on routes that cannot support the capacity of the larger types. AC