

The Bombardier C Series, Embraer E-Jets E2 and Mitsubishi MRJ families will all enter service in the next three years. The main operational and economic advantages of these aircraft are discussed along with their likely position in the market and the reasons customers have ordered them.

# New generation large RJs and small narrowbodies: What the C Series, E-Jets E2 and MRJ offer

**T**hree new aircraft families will enter service in the 70- to 160-seat market in the next few years: the Bombardier C Series, Embraer E-Jets E2, and Mitsubishi MRJ families.

The operational advantages and cost savings these aircraft bring are discussed.

## C Series

There are two variants in the C Series family: the CS100 and the CS300.

The CS100 is a 108-seat aircraft in a dual-class cabin, and a 120-seat aircraft in a standard single-class layout. It can accommodate up to 133 passengers (*see table, page 16*).

The CS100 will have a maximum take-off weight (MTOW) of up to 134,000lbs (*see table, page 16*). It will have a range of 3,100 nautical miles (nm) with a dual-class 108-passenger payload.

The CS300 will accommodate about 130 passengers in a typical dual-class arrangement, or 140 in a standard single-class layout. In a high-density, single-class configuration, the CS300 will seat up to 160 passengers (*see table, page 17*).

The CS300 has an MTOW of up to 149,000lbs and a range of 3,300nm with a 130-passenger load. Both variants will have five-abreast economy-class seating.

Bombardier says the C Series will offer lower fuel burn, emissions, noise levels and maintenance costs than current in-service aircraft, and expects the CS100 and CS300 to demonstrate fuel burn savings of about 20% per-seat compared to similar sized in-production aircraft.

The CS100 might be expected to burn 20% less fuel per seat than the E-190, E-195, A318 and 737-600.

The CS300 would be expected to demonstrate a similar fuel burn advantage over the A319 and 737-700.

Bombardier expects the C Series to maintain a fuel burn advantage of over 10% per-seat over re-engined designs.

This would include the E-Jets E2, A319neo and 737 MAX 7.

“New PW1000G family engines, and the use of 3-axis fly-by-wire, the fourth generation aerodynamics, the latest avionics for enhanced navigation, and lighter advanced materials, such as aluminium lithium and composites, will contribute to the C Series’ fuel burn advantage,” explains Sebastien Mullot, director of the C Series programme at Bombardier.

“The C Series design is completely optimised for the 100-150-seat market, so it is a lighter design that will burn less fuel than aircraft such as the A318, A319, 737-600 and 737-700, which are optimised around the larger 180-seat A320 and 737-800 variants.

“The C Series will have 25% lower maintenance costs than similar-size in-service aircraft,” claims Mullot.

“The new PW1000G family engines feature fewer stages and airfoils than current generation engines, resulting in reduced maintenance requirements,” continues Mullot. “In addition, 45-50% of the CS100’s and CS300’s airframe structures will comprise materials that are less prone to corrosion and fatigue than traditional alloys. This will allow us to start the maintenance programme with equivalent A and C check intervals of 850 and 8,500 flight hours (FH).” These are longer than standard initial intervals for in-production aircraft. The E-190/195, for example, have A and base check intervals of 750FH and 7,500FH.

Composite materials have been used in the wings, empennage, engine nacelles and the very aft section of the fuselage.

Bombardier estimates that the C Series will have a total cash operating cost advantage of 15% per seat over similar-size in-production aircraft, and a 10-12% advantage over new re-engined designs.

“The CS100 and CS300 will have similar seat-mile costs to larger

narrowbody aircraft while maintaining much lower trip costs,” claims Mullot. “This could make them attractive for new routes or services with thinner demand. We wanted to design an aircraft capable of meeting many needs,” says Mullot.

“The range of the C Series might appeal to US operators, since it can fly non-stop between the East and West Coasts. The level of cabin comfort could appeal to airlines in the Middle East, and the lower fuel burn and noise footprint might appeal to European airlines. Its field performance means that it can operate relatively long missions from short runways, making it suitable for hot and high environments.”

There are 53 CS100s and 190 CS300s on firm order. Bombardier expects to deliver the first CS100 to launch customer SWISS in the first half of 2016.

The CS300 is expected to enter airline service six months after the CS100. The largest orders for CS300s have been placed by Republic Airways Holdings and Macquarie AirFinance. They each have 40 aircraft on order backlog.

## E Jets E2

Embraer’s E-Jets E2 family will include three variants: the E-175-E2, E-190-E2 and E-195-E2. These will be next generation developments of the original E-175, E-190 and E-195. There will be no E2 variant of the E-170.

The E-175-E2 and E-195-E2 will feature a slight fuselage stretch, but the E-190-E2 will maintain the same fuselage dimensions as its predecessor.

The E-175-E2 will accommodate about 80 seats in a typical dual-class configuration, 88 in a standard single-class arrangement, and a maximum of 90 (*see table, page 14*). It will have an MTOW of up to 98,767lbs and a range of about 2,060nm with 88 passengers.

The E190-E2 will accommodate 97 passengers in a standard dual-class cabin



(see table, page 16). It will be capable of operating with 106 seats in a typical single-class configuration, or up to a maximum of 114. The E190-E2 will have an MTOW of up to 123,900lbs, and a range of 2,800nm with 106 passengers.

The E195-E2 will hold 120 seats in a dual-class configuration; 132 in a typical single-class configuration; or up to 146 in a high-density layout. The E195-E2 will have an MTOW of up to 129,411lbs and a range of up to 2,000nm with a 132-passenger payload (see table, page 17).

All three E-Jets E2 variants will feature four-abreast economy seating.

“With the E-Jets E2 we have invested in more than a simple re-engining programme,” explains Rodrigo Silva e Souza, vice president of marketing at Embraer Commercial Aviation. “As well as Pratt and Whitney’s PurePower® Geared Turbofan™ PW1000G family engines, the E-Jets E2 will feature new aerodynamically advanced, high-aspect ratio wings, and improved systems and avionics, including full fourth-generation fly-by-wire controls. These changes will result in double digit reductions in fuel consumption, emissions, noise, and maintenance costs compared to the current E-Jets. They will also lead to improved dispatch reliability.”

Embraer estimates that the E-175-E2 and E-190-E2 will be 16% more fuel-efficient per seat than the E-175 and E-190, and that the E-195-E2 will have a 24% lower fuel burn per seat than the E-195.

The E-Jets E2 are also expected to save up to 25% in maintenance costs per seat compared to the current generation E-Jets. “Some of this will be associated with the new engine technology, but

reduced airframe maintenance requirements will also be a key factor,” claims Souza. “The cost of scheduled maintenance tasks on the E-Jets E2 are expected to be 50% lower per FH. A and C check inspection intervals have already been escalated to 750 FH and 7,500 FH for the current E-Jets. For the E-Jets E2, we plan for these intervals to start at 850FH and 8,500 FH. Improved systems will lead to greater reliability and a reduction in component costs.”

The use of corrosion- and fatigue-resistant composite materials will contribute to the extended maintenance intervals. “Composite structures will be used for the wing fairing, radome and control surfaces, and will represent 12% of total structural weight,” says Souza.

The 50% lower cost per FH for airframe maintenance is nevertheless an ambitious target.

“Although there will only be 25% parts commonality between the original E-Jets and the E-Jets E2, the level of flight deck commonality will be high,” adds Souza. “This will make the E-Jets E2 appealing to current E-Jets operator. We also expect to capture new business owing to the substantial cost savings the E-Jets E2 will bring in comparison to some larger current-production jets.

“The E-195-E2 will have a 15% advantage over the A319neo and 737 MAX 7 in terms of fuel burn per trip and almost 10% better fuel burn per seat,” claims Souza. “The E-190-E2 is ideally sized for the 100- to 110-seat market, and will offer a 20% fuel burn per trip advantage over the A319neo and 737 MAX 7.”

Embraer does not see the E-Jets E2 as direct competition for narrowbodies.

The E-Jets E2 could be popular with existing E-Jets customers owing to the flightdeck commonality between the two families. Azul is the largest global operator of the E-195 and has subsequently placed the largest order for E-195 E2s.

“The E-Jets E2 are designed for different missions in terms of performance,” says Souza. “They will complement, rather than compete with, narrowbodies. The E-Jets E2 are focused on the 70-130-seat market, and in most cases are smaller and have shorter range than A320 and 737 family aircraft.

“The E-Jets E2 will offer significantly lower costs per trip than larger re-engined narrowbodies, and competitive costs per seat. They could complement an airline’s narrowbody fleet by offering right-sizing opportunities on existing routes, or a lower-risk alternative for developing new markets.”

There are 267 E-Jets E2s on backlog, including 100 E-175-E2s, 77 E-190-E2s and 90 E-195-E2s. The first E-Jets E2, an E-190-E2, is due for delivery in 2018. The first E-195-E2 and E-175-E2 will be delivered in 2019 and 2020. The largest order has come from SkyWest Airlines, which has 100 E-175-E2s on firm backlog.

## MRJ

The MRJ family is a new entrant to the regional jet (RJ) market and will initially include two variants: the MRJ70 and MRJ90. Mitsubishi Aircraft has also announced the potential, predicated on demand, for a stretched 100-seat aircraft; labelled the MRJ100X.

The MRJ70 will accommodate 69 passengers in a typical dual-class configuration or 76 in a standard single-class cabin (see table, page 14). It could hold up to 80 passengers.

The MRJ90 will hold 81 seats in a dual-class set-up, or 88 in a standard single-class cabin. The MRJ90 could hold up to a maximum of 92 passengers.

Both MRJ variants will feature four abreast economy seating.

There will be three versions available for each MRJ variant: standard (STD), extended-range (ER) and long-range (LR). The LR versions will have the highest MTOWs and longest-range capability.

The MRJ70LR will have an MTOW of 88,626, and a range of up to 1,820nm with a payload of 78 passengers.

The MRJ90LR will have an MTOW of 94,358lbs, and a range of up to 1,780nm with a payload of 92 passengers.

Mitsubishi claims that the MRJ70



and MRJ90 will bring savings in fuel, maintenance, and overall operating costs compared to the alternative RJs in operation, and that they will have a reduced noise footprint and CO2 emissions.

“The MRJ70 and MRJ90 can reduce fuel consumption by more than 20% per trip when compared to similar-size, in-service RJs,” claims Hideyuki Kamiya, director and head of strategic marketing, at Mitsubishi Aircraft Corporation.

“About half of this saving will come from the new Pratt and Whitney PurePower Geared Turbofan engines,” continues Kamiya. “The rest will come from the use of a high-aspect ratio wing, state-of-the-art aerodynamics and a small diameter fuselage that reduces drag.”

Mitsubishi also says the MRJ family will provide savings in maintenance costs when compared to current, in-service RJs. It does not elaborate on the extent of these savings, however.

“We are currently developing the MRJ maintenance programme in co-operation with airlines,” says Kamiya. “Maintenance costs will be reduced by use of fewer components, especially in the engines. Certain components will benefit from ease of access for maintenance.”

The use of composite materials in the airframe will contribute to the MRJ family’s longer maintenance intervals. These will be used in the tail, control surfaces and engine cowls, and will account for 8% of the structural weight.

Mitsubishi claims that an MRJ70 would save \$1.0 million in annual operating costs compared to an E-170. It adds that an MRJ90 would save \$2.8 million in annual operating costs compared to an E-190.

“During the next 20 years we believe

there will be a demand for 5,000 aircraft in the MRJ size category,” says Kamiya “We would like to get half of the share.

“Our main focus will be on North America and Europe. We are promoting the MRJ70 and MRJ90 in the US and Canada as replacements for the 50-seat RJ fleet. In Europe, a number of old Fokker and BAe RJs need to be replaced, so we are promoting the MRJ family for this purpose. We are also looking at Asia, which is the fastest growing market.”

There are 223 MRJs on firm order backlog, officially all for MRJ90s. But some customers including Japan Airlines (JAL), SkyWest Inc and Trans States Holdings, have the option to convert to MRJ70s. SkyWest has the largest number of MRJs on order with 100 aircraft.

The first MRJ is to be delivered to All Nippon Airways (ANA) in 2017.

## PW1000G

The C Series, E-Jets E2 and MRJ aircraft will all use versions of Pratt and Whitney’s new PurePower® Geared Turbofan™ PW1000G engine family.

The C Series will feature PW1500G series engines. The E-175-E2 will use PW1700G series engines while the E-190-E2 and E-195-E2 will be equipped with the larger PW1900G.

The MRJ family’s main feature is the PW1200G series engines. PW claims the PW1000G family is adding more than a 16% fuel burn improvement over current generation aircraft.

In the PurePower PW1000G engine family, a planetary gear system separates the engine fan from the low pressure compressor (LPC), allowing each module to operate at their optimum rotational speeds. This allows a wider diameter fan,

*SWISS is launch customer for the C Series. It will use some of the aircraft it has on order to replace Swiss Global Airlines’s fleet of ageing Avro RJs. SWISS expects the C Series to provide a 25% improvement in fuel burn.*

and the LPC and turbine to operate at a higher rotational speed. The increased efficiency is also enhanced by having 2,000 fewer airfoils and six fewer stages, including hot section parts that incur the highest maintenance costs.

The ultra-high bypass ratio of the PW1000G engine family allows the core to run cooler, adding more durability to the hot section, improving time on wing and lowering lifecycle maintenance costs.

The PW1000G family also incorporates advances in aerodynamics, lightweight materials and other improvements in the high-pressure spool, low pressure turbine (LPT), combustor, controls, and engine health monitoring.

## Competition

The C Series, E-Jets E2 and MRJ variants can be sub-categorised into approximate capacity groups based on their standard single-class capacity.

This highlights the jet aircraft they may compete with or replace. Turboprops are not considered here.

The capacity and range figures used here are based on manufacturer specifications. The range figures are only intended to offer a rough guide to performance, since a uniform comparison was not possible. Manufacturers may use different assumptions when calculating range, including aircraft configuration, operating conditions and the average weight of passengers and their baggage.

None of the quoted range figures are based on aircraft operating with a maximum payload; they are all based on aircraft operating with certain passenger and baggage payloads. The range figures for Embraer’s E-Jets and E-Jets E2, the SSJ100-95 and the CRJ-1000, are based on aircraft operating with typical single-class passenger payloads.

The range specifications for the MRJ70 and MRJ90, the Fokker 70 and Fokker 100, the CRJ700 and CRJ900, and the two BAe146/Avro RJ models are based on maximum single-class payloads.

Range figures for all C Series, Airbus and Boeing aircraft assume operations with a typical dual-class passenger payload.

## 70-90 seats

The two MRJ variants and the E-175-E2 will compete for orders in the 70- to 90-seat market. The active fleet in this

## 70-90-SEAT JET SPECIFICATIONS

New Aircraft	MRJ70	MRJ90	E-175 E2
Two-class seating	69	81	80
Std single-class seating	76	88	88
Max single-class seating	80	92	90
MTOW (lbs)	STD: 81,240 ER: 85,969 LR: 88,626	STD: 87,303 ER: 90,378 LR: 94,358	98,767
Range (nm)	STD: 820 ER: 1,470 LR: 1,820	STD: 900 ER: 1,290 LR: 1,780	2,060
Engine type	PW1200G	PW1200G	PW1700G
Order backlog	See notes	223	100

  

In-service aircraft	Fokker 70	CRJ-700	E-170	E-175	CRJ-900
Two-class seating	72	66	66	76	81
Std single-class seating		74	72	78	88
Max single-class seating	80	78	78	88	90
MTOW (lbs)	92,000	ER: 75,000	STD: 79,344 LR: 82,012 AR: 85,098	STD: 82,673 LR: 85,517 AR: 89,000	ER: 82,500 LR: 84,500
Range (nm)	1,800	ER: 1,378	STD: 1,800 LR: 2,100 AR: 2,150	STD: 1,750 LR: 2,150 AR: 2,200	LR: 1,553
Engine type	RR TAY620	CF34-8C5B1	CF34-8E	CF34-8E	CF34-8C5
In active service	38	317	175	291	341
Order backlog	0	9	5	165	38

## Notes:

- 1). There are 223 MRJs on order. These are listed as MRJ90s but some allow conversion to MRJ70s.
- 2). Aircraft capacity and range specs based on marketed manufacturer figures. Range specs are only guide and may be based on different assumptions.

size bracket includes CRJ-900s (341), CRJ-700s (317), E-175s (291), E-170s (175), and Fokker 70s (38).

The MRJ70 is most closely matched to the CRJ-700, E-170 and Fokker 70 (see table, this page).

The LR variant of the MRJ70 might offer similar range capability to a Fokker 70. It could offer more range than a CRJ700ER, but less than an E-170AR (see table, this page).

CRJ-700s and E-170s are still in production and are unlikely to be retired in large numbers in the near future. The Fokker 70 is the oldest 70-80-seat jet in service and, therefore, the most likely retirement candidate. The largest current operator of Fokker 70s is KLM Cityhopper (19). It has 15 E-175s on order and is, therefore, unlikely to be in the market for MRJ70s.

The MRJ90 and E-175-E2 will offer similar dual-class, single-class and high-density capacities of 80-90 seats (see table, this page). Their capacity is comparable to that of the CRJ-900 and the E-175.

The standard E-175-E2 could have a slight range advantage over the MRJ90 (see table, this page). Both aircraft could potentially offer more range than a CRJ-900, but less than an E-175AR.

There are currently 526 80-90-seat jets on order. The largest backlog is for MRJ90s (223), although some of these aircraft could be changed to MRJ70s.

The original E-175 (165) currently has a larger order backlog than the E2 variant (100). There are also orders outstanding for CRJ-900s (38).

The MRJ aircraft and the E-175 E2 may also be used to replace 50-seat RJs.

The main 50-seat RJ variants are the ERJ-145 and the CRJ-100/200, with more than 1,100 in service. Many are operated by US regionals on behalf of major carriers by way of capacity purchase agreements (CPAs). The size and number of aircraft that regional affiliates operate under CPAs can be determined by scope clause provisions. These offer a degree of job security for US mainline airline pilots by limiting the capacity that can be outsourced to regional aircraft.

Historically many scope clause provisions capped the size of RJs operating under CPAs at 50 seats. This partly explains why 50-seat RJs became so popular in the US market. More recently there has been a slight relaxation in scope clause restrictions and a trend among US mainline carriers for allowing the use of larger RJs with up to 76 seats. This has corresponded with a fall in the number of active 50-seat RJs and the introduction of E-175s and CRJ-900s in dual-class 76-seat cabins.

The MRJ aircraft and the E-175 E2 could be suitable candidates for US airlines looking to replace 50-seat RJs on CPA contracts with 76-seat scope limits.

## 95-125 seats

The E-190 E2 and CS100 can be grouped in the 95- to 125-seat category (see table, page 16). The active in-service aircraft in this category include the E-190 (505), 737-500 (195), 717-200 (142), E-195 (134), Fokker 100 (133), BAe 146-200/Avro RJ85 (77), BAe146-300/Avro RJ100 (72), SSJ100-95 (52), 737-600 (51), A318 (47) and CRJ-1000 (40).

The age of some of these types could result in near-term replacement needs. The E-190-E2 and CS100 could be suitable replacement candidates.

The E-190 E2 is at the smaller end of the 95- to 125-seat size category and is most closely matched to the SSJ100-95, BAe146-200/Avro RJ85, CRJ-1000, E-190, and Fokker 100 in terms of capacity (see table, page 16). It could offer greater range than all of these aircraft.

The backlog for E-190-E2s stands at 77 compared to 106 for the SSJ100-95, 66 for the original E-190 and 28 for the CRJ-1000. The BAe146-200/Avro RJ85 and Fokker 100 are no longer in production. The E-190-E2 will offer slightly fewer seats than the 717-200, and the BAe 146-300/Avro RJ100, but will offer more range (see table, page 16).

The BAe 146-200/Avro RJ85 and the Fokker 100 are the most likely near-term replacement candidates in the E-190-E2's immediate size bracket.

The largest operators of Fokker 100s

## 95-TO 125-SEAT JET SPECIFICATIONS

New aircraft				E-190 E2	CS100		
Two-class seating				97	108		
Std single-class seating				106	120		
Max single-class seating				114	133		
MTOW (lbs)				123,900	Base: 121,000 Max: 134,000		
Range (nm)				2,800	3,100		
Engine type				PW1900G	PW1500G		
Order backlog				77	53		
In-service aircraft		SSJ100-95	BAe 146-200 /Avro RJ85	CRJ-1000	Fokker 100	E-190	
Two-class seating		87		97	97	96	
Std single-class seating		98	100	100		100	
Max single-class seating		108		104	109	114	
MTOW (lbs)		B: 101,150 LR: 109,019	93,000	ER: 91,800	98,000 - 101,000	STD: 105,359 LR: 110,893 AR: 114,199	
Range (nm)		B: 1,645 LR: 2,470	1,200/1,328	ER: 1,622	1,450	STD: 1,850 LR: 2,400 AR: 2,450	
Engine type		PowerJet SaM146 ALF502R-5/LF507-1F		CF34-8C5A1	RR TAY 620/650	CF34-10E	
In active service		52	77	40	133	505	
Order backlog		106	0	28	0	66	
In-service aircraft		E-195	BAe 146-300 /Avro RJ100	717-200	737-500	737-600	A318
Two-class seating		100		106	110	110	107
Std single-class seating		116	112	117	122	123	
Max single-class seating		124			132	130	132
MTOW (lbs)		STD: 107,564 LR: 111,973 AR: 115,280	97,500	110,000-121,000	115,500-133,500	124,000-145,500	123,459-149,914
Range (nm)		STD: 1,600 LR: 2,000 AR: 2,300	1,150	1,695	2,390	3,235	3,100
Engine type		CF34-10E	ALF502R-5/ LF507-1F	RR BR715	CFM56-3	CFM56-7B	CFM56-5B/ PW6000A
In active service		134	72	142	195	51	47
Order backlog		24	0	0	0	0	0

## Notes:

1). Aircraft capacity and range specs based on marketed manufacturer figures. Range specs are rough guide only. They may be based on different assumptions

are Austrian Airlines (15 aircraft), Alliance Airlines (15), Virgin Australia Regional (12) and Network Aviation (12).

The largest operators of the BAe 146-200/Avro RJ85 are CityJet (17) and Airlink (12).

The CS100 is most closely matched to the 737-500, 737-600 and A318 in terms of capacity (see table, this page). It will offer superior range to the 737-500 and similar range to the 737-600 and A318. The CS100 is the only type on order.

The largest 737-500 operators include UTair (31), ANA Wings (17), Southwest Airlines (12) and Sriwijaya Air (12). The active fleets of 737-600s and A318s are spread over a small operator base since so few aircraft were built. SAS (26), WestJet (13), Tunisair (7) and Air Algerie (5) are the only operators of 737-600s. The A318 fleet is operated by Air France (18), Avianca Brazil (13), Avianca (10), TAROM (4) and British Airways (2).

The CS100 will offer slightly more capacity than the E-195, 717-200 and BAe 146-300/Avro RJ100 (see table, this page). It will also provide greater range capability than these aircraft.

The order backlog for CS100s stands at 53 aircraft. There are 24 original E-195s on order, but the 717-200 and BAe 146/Avro RJ100 are out of production.

The BAe 146-300/Avro RJ100 fleet is a likely candidate for replacement in the near future, owing to the uncompetitive fuel burn and maintenance costs of a four-engine aircraft. The largest BAe146-300/Avro RJ100 operators are Swiss Global Air Lines (17), Brussels Airlines (12), Mahan Air (12) and Malmo Aviation (10). Swiss Global Air Lines and Malmo Aviation have already indicated their intent to replace their Avro RJ100s with CS100s.

The 717-200 could be another contender for replacement, but Delta Air Lines, the largest operator of the type

with 77, seems to have no intention of removing the aircraft from service. The next largest 717-200 operators are Volotea (19) and Hawaiian Airlines (18).

## 130-160 seats

The E-195-E2 and CS300 can be grouped in the 130-to-160-seat category. The active fleet in this segment is dominated by the A319 (1,330) and the 737-700 (1,044), still in production. There are also 345 737-300s in service. The 737 MAX 7 and A319neo will add competition in this size category.

In standard dual and single-class arrangements the CS300 offers similar capacity to the 737-300, 737-700, 737 MAX 7, A319 and A319neo (see table, page 17). In a high-density configuration it can hold more seats than the Boeing and Airbus aircraft.

The CS300 may offer slightly less range than the 737-700 or A319 (see

table, this page). It is also likely to offer less than the 737 MAX 7 and A319neo.

There are more CS300s (190) on order than 737 Max 7s (60) 737-700s (46), A319neos (39) and A319s (24).

The relative lack of orders for current and future Airbus and Boeing products in this size category indicates that 737-700 and A319 operators are turning their attention to larger models. The largest operator of A319s is easyJet (135). It has already begun to add capacity by supplementing its fleet with the larger A320 and its order book is focused on the A320 (51) and A320neo (100). The largest operator of 737-700s is Southwest (449). It has been adding the larger 737-800 to its fleet and its largest outstanding order is for the 737 MAX 8.

Despite the trend for operators to move toward larger aircraft, some 737-700 or A319 operators may not require additional capacity, and so may be attracted by the CS300's economics. Swiss International Airlines has intimated using some of the CS300s it has on order to replace mainline aircraft on certain services. This is most likely to refer to the airlines' A319s or A320s.

It appears that some operators will use the CS300 to replace smaller aircraft. Malmo Aviation has five on order as part of its Avro RJ fleet replacement plan.

The E195-E2 is at the low end of the 130-160-seat capacity group with typical single-class seating for 132 passengers. It would, therefore, offer less capacity than the other aircraft in this category. It is also likely to have shorter range than these aircraft (see table, page 17).

The E-195-E2 is almost in a category of its own. It is larger than the aircraft in the 95-125-seat group, but smaller than competing 130-160-seat types. Embraer has intimated that it sees the E-Jets E2 family as complementing, rather than competing with, mainline narrowbodies. The E-195 E2's estimated range performance suggests it has not been designed to compete directly with the other types in this category. The E-195 E2 may be seen as an option to complement larger types on shorter routes with less demand.

There is evidence to suggest that there will be demand for E-195 E2s from airlines looking to replace or complement fleets of smaller RJs. There are 90 E-195 E2s on order. More than half are on order with current E-Jets operators. The biggest order for the E-195-E2 is with Azul (30), which is already the largest E-195 operator.

## The customers

A number of case studies of C Series, E-Jets E2 or MRJ customers are included here. These identify some of their main reasons for ordering these new aircraft.

## 130-160-SEAT JET SPECIFICATIONS

New Aircraft	E195 E2	CS300	737 MAX 7	A319neo
Two-class seating	120	130	126	124
Std single-class seating	132	140	140	134
Max single-class seating	146	160	149	156
MTOW (lbs)	129,411	Base: 132,000 Max: 149,000	159,500	141,096-166,449
Range (nm)	2,000	3,300	3,850	4,200
Engine type	PW1900G	PW1500G	CFMI LEAP 1-B	CFMI LEAP 1-A/ PW1100G
Order backlog	90	190	60	39
In-service aircraft	737-300	737-700	A319	
Two-class seating		126	126	124
Std single-class seating		140	140	134
Max single-class seating		149	149	156
MTOW (lbs)	124,500-138,500	133,000-154,500	136,686-168,653	
Range (nm)	2,260	3,445 (Winglets)	3,700 (Sharklets)	
Engine type	CFM56-3	CFM56-7B	CFM56-5B/ V2500	
In active service		345	1,044	1,330
Order backlog		0	46	24

### Notes:

i). Aircraft capacity and range specs based on marketed manufacturer figures. Range specs are rough guide only. They may be based on different assumptions.

## Azul

Azul is Brazil's third largest airline, offering more than 900 daily flights to over 100 destinations. Most of its capacity is offered on domestic services, and it serves more domestic destinations in Brazil than any other airline. Azul also has one-third of all daily departures in the Brazilian commercial aviation market.

Azul has a fleet of 136 aircraft. This includes ATR72-600s (45), E-190s (22), E-195s (62) and A330-200s (7). Azul has 30 E-195 E2s on backlog with options for 20 additional aircraft. It expects to receive its first E-195-E2 in 2020.

"Our partnership with Embraer has been fundamental to Azul's success from the very beginning," says Flavio Costa, chief operating officer at Azul. "Since 2008 the E-Jets have enabled Azul's exponential growth, resulting in the creation of an entirely new market for domestic air travel."

Azul's selection of the E-195 E2 suggests it sees advantages in having commonality with its current fleet.

Azul says it is yet to decide whether the E-195-E2s will replace or grow the current fleet; its decision will depend on future demand. It suggests the new aircraft will be used on domestic services, and that they will have more capacity than the E-195 fleet.

## Malmo Aviation

Sweden's Malmo Aviation has a fleet of 12 aircraft: two 97-seat Avro RJ85s, and 10 112-seat Avro RJ100s.

Malmo Aviation operates high-

frequency, scheduled domestic services between its main base at Bromma Stockholm Airport (BMA) and Gothenburg, Malmo, and Umeå, plus ad hoc charter flights internationally.

The airline has 10 C Series aircraft on order, split between CS100s (5) and CS300s (5). It has the option to vary this split between the two variants and has not yet decided on the final fleet mix, although it will definitely take delivery of CS100s first.

The first CS100 is expected to arrive in early 2018 and the remaining C Series aircraft are due over the next 12 months.

The C Series aircraft have been ordered to completely replace the existing fleet of Avro RJ85s and RJ100s. Malmo Aviation plans to configure its CS100s with 125 seats in a single-class arrangement with a 30-inch seat pitch, providing 28 more seats than the airline's RJ85s and 13 more than its RJ100s.

The most pressing reason for selecting the C Series as a fleet replacement is associated with operational restrictions at the airline's main base.

BMA is a city airport located close to the centre of Stockholm, so it is subject to stringent environmental controls. The airport has strict noise emission standards based on a maximum noise level of 86 decibels (dBs). It grants an annual exemption for 20,000 commercial movements with noise emissions in the 86-89 dB range.

Malmo Aviation claims that the movement quota is practically taken up, limiting potential for expansion. The airline parks four to six aircraft a day for up to five hours, partly due to demand



waves, but also the movement quota.

The C Series is expected to meet the noise threshold requirements at BMA. This means it will not be subject to the movement quota, and will subsequently allow Malmo Aviation to expand its services and increase aircraft utilisation.

Malmo Aviation also wanted to lower fuel and maintenance costs significantly. It believes the C Series will deliver up to a 30% reduction in fuel burn per seat and a 25-30% reduction in maintenance costs compared to the Avro RJ fleet.

The final factor in Malmo Aviation's decision to select the C Series was a need for the flexibility to operate short sectors, and longer scheduled and charter routes. The runway at BMA is only 5,400 feet, which can restrict take-off weight and limit range. Malmo Aviation believes the C Series' short field performance will add flexibility to the routes it can operate from BMA and Scandinavia.

### SkyWest Inc

SkyWest Inc is the holding company for large US regional operators SkyWest Airlines and ExpressJet. These provide feeder services in partnership with US majors.

SkyWest Airlines operates under CPAs with United, Delta, American and Alaska Airlines. ExpressJet also operates on behalf of United, Delta and American.

SkyWest Inc has 100 MRJs and 100 E-175-E2s on order, as well as another 32 original E-175s. In terms of the MRJs and E-175-E2s, it has not yet decided which aircraft will be delivered to which operating airline, or in what quantity. "This will be determined by the flying

contracts awarded to each operating entity," explains Wade Steel, chief commercial officer at SkyWest Inc.

SkyWest Inc's MRJ order does not define variants or quantities. "The option is for either MRJ variant, depending on scope availability," says Steel.

"The MRJ and E-175-E2 orders depend on flying agreements," explains Steel. "Finalisation of orders requires contract agreements with major carriers. If those are secured, the first MRJ is due for delivery in Q2 2018, and the first E-175-E2 by Q1 2020.

"These orders are part of our overall fleet optimisation plan. The MRJs and E-175-E2s will most likely replace some of the SkyWest or ExpressJet fleets. They may also be used for growth," he adds.

The most likely replacement candidates are 50-seat RJs.

ExpressJet operates 182 ERJ-145s and 76 CRJ-200s, while SkyWest Airlines operates 162 CRJ-100/-200s.

Changing trends in scope clause provisions have led to an increase in the seat capacity of aircraft that can be operated by regional carriers on behalf of US majors under CPAs. The long-term trend has been for a capacity limit rise from 50 to 76 seats, but this can vary.

This trend may lead to the accelerated retirement of ageing 50-seat RJs in favour of larger aircraft. ExpressJet already operates CRJ-900s, and SkyWest Airlines has added CRJ-900s and E-175s to its fleet. Both carriers operate these aircraft with 76 seats in the dual-class configuration preferred by the majors.

MRJ90s and E-175-E2 could provide similar seat capacity in a dual-class arrangement.

*The MRJ family is due to enter service with launch customer ANA in 2017. Mitsubishi believes the MRJ70 and MRJ90 could be effective replacements for the large 50-seat RJ fleet in the US.*

### SWISS

Flag carrier Swiss International Airlines (SWISS) has 30 C Series aircraft on order for its 100% owned subsidiary Swiss Global Air Lines. This includes 10 CS100s and 10 CS300s. SWISS is yet to determine the variant for the final 10.

Swiss Global Air Lines operates a fleet of 18 Avro RJ100s to 30 destinations across Europe on behalf of SWISS. From January 2016 it will also operate nine 777-300ERs on long-haul services on behalf of its parent company.

"The first 18 CS100s will replace Swiss Global Air Lines' Avro RJ100s," says Peter Koch, fleet chief and programme manager for the C Series at SWISS. "The remaining CS100s and the CS300s will be used for moderate growth, or to replace SWISS mainline aircraft on certain routes.

Swiss Global Air Lines will configure its CS100s with 125 seats in a single-class configuration. It is finalising the layout for the CS300s. "The C Series will set new standards in operating economics and environmental features," says Koch.

"The C Series will use up to 25% less fuel than the Avro RJ100, and cut annual carbon dioxide (CO<sub>2</sub>) emissions by 90,000 tonnes, equivalent to the CO<sub>2</sub> emitted by 7,000 flights between Zurich and London City airport (LCY)," adds Koch. "A C Series aircraft is also 10-15 dB quieter than an Avro RJ100. This is equivalent to halving the noise level to the human ear. At many European airports, lowering the noise level will be crucial.

"The short field performance was key to our selecting the C Series," adds Koch. "It allows it to operate effectively from airports with short runways like LCY, which is an important destination for us." LCY's relatively short runway limits the types certified to operate from there.

Koch suggests that the C Series will initially be used on existing routes, but their short-field performance could open up new opportunities. "The first CS100s will replace the Avro RJ100s, so the CS100s will fly the present RJ routes. Their flexibility means C Series aircraft can operate relatively long-range sectors from short runways. This is ideal for network development." **AC**

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