The active fleet of large RJs has more than trebled since the beginning of the millennium. A summary of specifications and programme status is provided here for those types in production and in development. Potential market demand and influencing factors on RJ fleet planning are discussed.

An evaluation of the large regional jet market

The passenger-configured regional jet (RJ) fleet has grown rapidly since the turn of the millennium.

Over the past 10 years there has been a pronounced move away from 50-seat RJs towards larger types, classified here as those with 70 seats or more. According to Flightglobal's Fleets Analyzer, large RJs accounted for only 37% of the in-service RJ fleet in February 2007. In 2017 they account for 68% of active RJs.

Aircraft Commerce has analysed the large RJ market to establish available solutions, and those that are due to enter service soon. In each case, some main specifications are summarised and the latest programme status and developments are identified. Potential future market trends are also discussed. Only those large RJ programmes that remain in production or are in development are considered.

All fleet and order numbers used in this analysis are accurate as per Fleets Analyzer data from 16th/17th February 2017. All order figures refer to the end operator, rather than the owner.

RJs in production & in service

Three large RJ families are both in service and in production: Bombardier's CRJ series; Embraer's E-Jet family; and Sukhoi Superjet's SSJ100. Comac's ARJ21 can also be classified as a large RJ, but it was not possible to obtain any detailed information on this programme.

CRJ series

Bombardier's CRJ series is the longest-running RJ family to remain in production. It has also been the most successful, with more than 1,900 aircraft ordered and delivered. The CRJ series family includes the CRJ100/200 series, CRJ700 series, CRJ900 series and CRJ1000 series. The CRJ100/200 series entered service in the 1990s, but because they are 50-seat aircraft they are not considered in this analysis.

"The CRJ700 series is an evolution of the CRJ200 platform," explains Kevin Smith, vice president for regional aircraft at Bombardier Commercial Aircraft. "The CRJ700 is basically an all-new aircraft with new engines, a new stretched fuselage, a new empennage and horizontal tail, a new wing, new landing gear and a re-designed flightdeck. Some design features from the CRJ200 have, however, been maintained to ensure flightdeck and maintenance commonality. The CRJ900 series is a further evolution of the CRJ700, with upgraded engines and an extended and reinforced fuselage, as well as new winglets, wing tip extensions, slat and flap upgrades and enhanced anti-skid braking systems."

The first CRJ700 series aircraft entered service in 2001, while entry into service (EIS) for the CRJ900 series took place in 2003.

"Since 2007, all CRJs coming off the production line have featured NextGen enhancements," explains Smith. "The NextGen build standard features an upgraded interior and efficiency improvements, and first became available for the CRJ900 series. NextGen aircraft offer an enhanced passenger experience with LED lighting, larger windows and lavatories, more comfortable seating, and in-seat power supply. To improve performance, the NextGen upgrade also includes installation of canted winglets, and computerised flight planning with optimised allowances. These result in 4% lower fuel burn." The NextGen enhancements have been standard for all production CRJ1000s. They were also made available for the CRJ700 series, although these aircraft do not feature the winglet modification.

"The CRJ1000 is a stretched variant of the CRJ900 NextGen, with an avionics upgrade, command-by-wire rudder and a take-off thrust increase," adds Smith.

The first CRJ900 NextGen entered service in 2007, followed by the first CRJ700 NextGen in 2008. The CRJ1000 entered service in 2010. Today all CRJs are built to NextGen standard, and are simply referred to as the CRJ series or the CRJ700, CRJ900 or CRJ 1000 series.

All CRJ700s, CRJ900s and CRJ1000s have the same cross-section and cabin width of 8ft, 4-inches. They can seat up to four abreast in economy.

CRJ700 series aircraft have a fuselage length of 106ft, 1-inch and can accommodate 66, 74 or 78 seats in typical dual-class, single-class or high-density configurations *(see table, page 20)*. The CRJ700 series is available in standard or extended range (ER) configurations. A standard CRJ700 has a maximum take-off weight (MTOW) of 72,750lbs and a range of up to 1,092 nautical miles (nm) with a full single-class passenger payload. An ER variant has an MTOW of up to 75,000lbs, and a range of up to 1,378nm with the same payload. Both the standard and ER CRJ700 variants offer a gross structural payload of up to 18,055lbs. Several sub-variants of the CRJ700 are available: the CRJ700, CRJ701 and CRJ702. These different model numbers were created in light of scope clause requirements in North America and seat 68, 70 and 78 passengers respectively.

There are 285 CRJ700 series aircraft in active passenger service, including 232 CRJ701s, and 53 CRJ702s. The largest CRJ700 series operators are SkyWest Airlines (85), GoJet Airlines (47) and ExpressJet Airlines (40).

CRJ900 series aircraft are almost 13 feet longer than the CRJ700 series. This allows them to accommodate up to 81, 88 and 90 seats in typical dual-class, single-class and high-density configurations. Many US-based regional operators configure CRJ900s with multi-class 76-seat arrangements. Standard, ER and long-range (LR) variants of the CRJ900 are available. There is also a special edition variant called the CRJ705, which was developed for Air Canada and is configured with 75 seats in a two-class arrangement. The MTOW ranges from

The CRJ series includes the CRJ700, CRJ900 and CRJ1000 series. The CRJ900 is one of the largest RJs operated by US regional airlines on behalf of the major carriers. These airlines generally configure the aircraft with 76 seats in multi-class configurations.

80,500lbs for a standard CRJ900 to 84,500lbs for an LR aircraft. The CRJ900's range with a maximum single-class passenger and baggage payload varies from 1,070nm for a standard variant to 1,553nm for an LR aircraft. The maximum structural payload is up to 21,840lbs for a standard or ER variant and up to 22,590lbs for a CRJ900LR.

There are 403 CRJ900 series aircraft in service, including 185 ER variants, 202 LR examples and 16 CRJ705s. The largest CRJ900 operators are Endeavour Air (81), Mesa Airlines (64) and PSA Airlines (54).

The CRJ1000 series has a fuselage length of 128 ft, 5-inches, making it 9ft, 6-inches longer than a CRJ900. The CRJ1000 is able to accommodate 97, 100 or 104 passengers in typical dual-class, single-class or high-density seating arrangements.

Three variants of the CRJ1000 are available: the standard baseline aircraft, the Eurolite (EL) variant and the ER variant. The EL variant has lower certified weights than standard or ER aircraft. It is designed to operate in Europe, where airport and navigation charges are based on MTOW, rather than maximum landing weight (MLW) as in the US. The MTOW of a CRJ1000 can vary from 85,968lbs for the EL variant to 91,800lbs for the ER aircraft.

All three variants offer a maximum structural payload of up to 26,380lbs, but the available range with a full single-class passenger and baggage payload varies from 971nm for the EL variant to 1,622nm for a CRJ1000ER.

There are 51 CRJ1000s in service: 14 EL and 37 ER aircraft. Most CRJ1000s are operated by Air Nostrum (18), Garuda Indonesia (18) and HOP! (14).

There are 61 firm orders outstanding for the CRJ family: nine CRJ700 series, 35 CRJ900 series and 17 CRJ1000 series aircraft. Felix Airways has the largest outstanding order for CRJ700s with six aircraft. Two of the largest orders for CRJ900s will see aircraft destined for China Express Airlines (10) and CityJet (8), while all of the outstanding CRJ1000s are destined for Air Nostrum.

"Over the past decade Bombardier has continuously invested in the CRJ family," says Smith. "In 2014 further enhancements were made to the CRJ900 NextGen aircraft that improved fuel burn by 5.5% compared to the original CRJ900. These included weight reductions and an exhaust nozzle upgrade for the engines." All CRJ700, CRJ900 and CRJ1000 series aircraft are powered by variants of the CF34-8C series engine.

"We are anticipating operators' needs to better accommodate passengers and distinguish their fleet," continues Smith. "The next enhancements to the CRJ family will focus on delivering a new cabin design, including a new entrance area, integrated connected cabin solutions, featuring the option for on-board WiFi, new mood lighting, more spacious lavatories and enhanced passenger living space. The new design will allow rapid boarding and deplaning," adds Smith. "The cabin will allow 50% more space for carry-on bags in business class thanks to new larger overhead bins. The main cabin will also benefit from larger overhead bins."

CRJ maintenance intervals have also been extended since the first aircraft entered service. "When the first CRJ700 entered service the A and C check intervals were 400FH and 4,000FH," explains Smith. "These were subsequently increased to 600FH and 6,000FH for both the CRJ700 and CRJ900 NextGen in 2008. With the on-going improvement to the platform, Bombardier is now offering intervals twice as long as the initial check periods. In 2016 the A check interval for the CRJ700, CRJ900 and CRJ1000 series was escalated to 800FH, and the C check interval will soon be extended to 8,000FH. The new maintenance intervals can also be applied to pre-NextGen 'Classic' aircraft."

Contemporary original equipment manufacturer (OEM) maintenance planning documents (MPDs) are based on maintenance steering group three (MSG3) principles. Each maintenance task is assigned an inspection interval rather than being pre-grouped in a letter check format, allowing operators to group tasks into checks to suit utilisation. Some operators prefer to maintain the equivalent of a traditional letter check base cycle.

The MPD for CRJ700s, CRJ900s and CRJ1000s can be customised according to an operator's preference. Tasks can be grouped into letter checks or given individual inspection intervals so that they can be grouped at the operator's discretion according to its utilisation.

E-Jet family

Embraer's original E-Jet family was launched in 1999, and entered service between 2004 and 2006. There are two types and four different series models of E-Jet. The E170 and E175 are officially classified as one type with the same type certificate, while the E190 and E195 are also classified as a single type. There are 1,203 E-Jet family aircraft in commercial passenger service.

All members of the E-Jet family share the same cross-section with a cabin width of 9 ft. This allows them to offer four-abreast seating in economy. For each E-Jet model there is the option to certify aircraft as standard (STD), long-range (LR) or advanced range (AR) variants.

The E170 is the smallest member of the family with a fuselage length of 98ft, 1-inch. It can accommodate up to 66, 72 and 78 seats in typical dual-class, single-class and high-density configurations *(see table, page 20)*. The MTOW of an E170 can vary from 79,344lbs for an STD variant to 85,098lbs for an AR version.

The maximum structural payload is up to 19,883lbs for a STD or LR variant,

SPECIFICATIONS FOR LARGE RJS IN SERVICE AND IN PRODUCTION

Aircraft type	CRJ700	E170	CRJ900	E175
Engine type	CF34-8C5B1	CF34-8E5	CF34-8C5	CF34-8E5
MTOW (lbs)	STD: 72,750	STD: 79,344	STD: 80,500	STD: 82,673
	ER: 75,000	LR: 82,012	ER: 82,500	LR: 85,517
		AR: 85,098	LR: 84,500	AR: 89,000
Max structural payload (lbs)	18,055	STD/LR:19,883	STD/ER: 21,840	STD/LR: 22,078
		AR: 21,515	LR: 22,590	AR: 22,695
Two-class seating	66	66	81	76
Standard single class	74	72	88	78
Max single class	78	78	90	88
Seats abreast (econ)	2+2	2+2	2+2	2+2
Cargo (cu ft)	547	508	594	605
Range (nm)	STD: 1,092	STD: 1,800	STD: 1,070	STD: 1,750
	ER: 1,378	LR: 2,100	ER: 1,317	LR: 2,150
		AR: 2,150	LR: 1,553	AR: 2,200
Fuselage length (ft)	106 ft, 1-inch	98ft, 1-inch	118ft, 11-inches	103ft, 11-inches
Cabin width (ft)	8ft, 4-inches	9ft	8ft, 4-inches	9ft
In service	285	147	403	420
On order	9	3	35	94

Aircraft type	CRJ1000	SSJ100	E190	E195
Engine type	CF34-8C5A1	SaM146	CF34-10E5	CF34-10E5
MTOW (lbs)	EL: 85,968	Basic: 101,150	STD:105,359	STD: 107,564
	STD: 90,000	LR: 109,019	LR: 110,893	LR: 111,973
	ER: 91,800		AR: 114,199	AR: 115,280
Max structural payload (lbs)	26,380	26,995	28,800	30,716
Two-class seating	97	87	97	100
Standard single class	100	98	106	118
Max single class	104	103	114	124
Seats abreast (econ)	2+2	2+3	2+2	2+2
Cargo (cu ft)	683	768.6	799	906
Range (nm)	EL: 971	Basic: 1,645	STD: 1,850	STD: 1,600
	STD: 1,425	LR: 2,470	LR: 2,400	LR: 2,000
	ER: 1,622		AR: 2,450	AR: 2,300
Fuselage length (ft)	128ft, 5-inches	98ft, 3-inches	118ft, 11-inches	126ft, 10-inches
Cabin width (ft)	8ft, 4-inches	10ft, 6-inches	9ft	9ft
In service	51	79	486	150
On order	17	56	56	11

Notes:

1). Range based on individual OEM assumptions that could vary by manufacturer- Independent enquiries should be made when comparing types.
2). In-service fleet and order numbers taken from Flightglobal Fleets Analyzer - Accurate as of 16/17th Feb 2017. In-service fleet does not include stored aircraft. Firm orders only.

and up to 21,515lbs for an E170 AR variant. The E170's range with a maximum single-class passenger and baggage payload varies from 1,800nm for an STD variant to 2,150nm for an E170 AR. There are 147 E170s in active passenger service and the largest operators are Republic Airlines (54), J-Air (17) and HOP! (15).

The E175's fuselage is nearly six feet longer than that of the E170, allowing it to accommodate up to 76, 78, or 88 seats in typical dual-class, single-class or high-density seating arrangements. An E175's MTOW varies from 82,673lbs for STD aircraft to 89,000lbs for one certified at AR weights. The STD and LR variants of an E175 offer a maximum structural payload of up to 22,078lbs, while the AR variant offers up to 22,695lbs.

The range of an E175 loaded with its maximum single-class passenger and baggage payload varies from 1,750-2,200nm, depending on the variant.

There are 420 E175s in passenger service, although it appears that one does not fly with a commercial airline. The largest operators are Republic Airlines (116), SkyWest Airlines (90), Compass Airlines (56) and Mesa Airlines (48).

The E190 has been the most popular family member to date, with more than 500 delivered. This series has a fuselage length of 118ft, 11-inches, which allows it to accommodate up to 97, 106, or 114 seats in dual-class, single-class or high-density arrangements. All E190 variants offer a maximum structural payload of up to 28,800lbs. The MTOW varies from 105,359lbs for an STD variant to 114,199lbs for an E190 AR. The corresponding difference in range for an aircraft operating with a maximum single-class passenger and baggage payload varies from 1,850 to 2,450nm, depending on the variant.

The in-service fleet of E190s stands at 486 aircraft. The largest operators are jetBlue Airways (60), Aeromexico Connect (38), Tianjin Airlines (37) and KLM Cityhopper (30).

The largest member of the family is the E195, with a fuselage almost eight feet longer than the E190. The E195 can hold up to 100, 118 or 124 passengers in typical dual-class, single-class or high density seating arrangements.

All E195 variants have a maximum structural payload of up to 30,716lbs. The MTOW of an E195 can vary from 107,564lbs for an STD variant, to 115,280lbs for an AR variant. The maximum range with a full single-class passenger and baggage payload will therefore be 1,600-2,300nm.

There are 150 E195s in active passenger service, with Azul (64) operating over 40% of this fleet. Other significant operators include Lufthansa CityLine (12), Air Dolomiti (10) and Austrian (10).

The E-Jet family is exclusively powered by CF34 family engines. The E170 and E175 are both equipped with CF34-8E5 series engines, while the larger E190 and 195 are powered by higher-thrust CF34-10E5 series engines.

There are 164 E-Jets on firm order, including three E170s, 94 E175s, 56 E190s and 11 E195s. The E170s are for J-Air, while most of the E175s are

The SSJ100 has the widest cabin of any RJ in production or in development. This allows it to be configured with five-abreast seating in economy. In 2013 Mexico-based Interjet became the first Western customer for the aircraft.

destined for Horizon Air (33), Republic Airlines (24) Envoy Air (11) and KLM cityhopper (11). The E190s on order include 24 for jetBlue and 20 for lessor Nordic Aviation Capital. All E195s are destined for Tianjin Airlines.

Since the first E-Jet aircraft entered service in 2004 there have been a number of developments. These include fuel burn reductions, improvements in hot-and-high performance, upgraded avionics in the form of a new flight management system (FMS), steep approach capability, and Category (CAT) III instrument landing system (ILS) capability. Embraer is studying connectivity options for the original E-Jets family.

There has also been an escalation of typical MPD task intervals. "For current-generation E-Jets, we have escalated the intervals for typical A and C check inspections to 750FH and 7,500FH from 650FH and 6,500FH when they first entered service," explains Rodrigo Silva e Souza, vice president of marketing at Embraer Commercial Aviation.

E-Jet MPD tasks are given individual inspection intervals allowing operators the flexibility to group them into checks. No significant developments are planned for the original E-Jet family since it will be replaced by the new E-Jets E2 models.

Sukhoi Superjet 100

The SSJ100 is manufactured by the Sukhoi Civil Aircraft Company (SCAC) with the support of Superjet International, which acts as a completion and delivery centre for Western SSJ100 customers and also offers after-sales support and training.

The current SSJ100 model is the only one available in the SSJ100 family. SCAC had intended to offer an additional smaller model referred to as the SSJ100-75. Although detailed design work was carried out, SCAC decided that market demand does not warrant production.

The SSJ100 has a fuselage length of 98ft, 3-inches and a cabin width of 10ft, 6-inches, giving it the widest interior of any large RJ *(see table, page 20)*. It can accommodate 87, 98 and 103 seats in typical dual-class, single-class and high-density seating arrangements and offers five-abreast seating in economy.

There are basic (B) and long-range (LR) variants of the SSJ100. Both offer a maximum structural payload of up to 26,995lbs. The B variant has an MTOW of 101,150lbs. The LR variant has a higher MTOW of 109,019lbs, which contributes to its longer-range capability. The LR variant can operate sector lengths of up to 2,470nm with a full passenger and baggage payload, while the B variant has a range of up to 1,645nm.

The SSJ100 is powered by SaM146 engines which are produced by Powerjet, a collaboration between Safran Aircraft Engines and NPO Saturn. The SSJ100B is equipped with SaM146-1S17 engines, while the LR variant is powered by the SaM146-1S18.

The SSJ100 entered commercial service in April 2011. There are 79 aircraft in passenger service, with another 11 in storage. Fleet data suggests that several of these may not be operating for commercial airlines. The largest SSJ100 operators are Aeroflot (29), Interjet (21) and Gazpromavia (10). Interjet became the first Western customer for the SSJ100 when it put the aircraft into service in 2013. It has been joined by Cityjet, which has taken delivery of three of an initial order for 15 aircraft.

Before the SSJ100's EIS, SCAC's marketed performance target was for the aircraft to demonstrate 10% savings in terms of cash operating costs per trip when compared to existing RJ solutions with similar capacity. SCAC claims that the SSJ100's in-service performance has met expectations, and in some cases has exceeded this target, although it did not provide any specific data to support this.

The SSJ100 has a base check cycle consisting of four main checks. Typical check intervals are: 750 flight hours (FH) or 100 days for the equivalent of an A check; 7,500FH, 6,000FC or two years for the equivalent of a C check; and 24,000FC or eight years for the equivalent of a heavy 4C or D check.

SCAC admits that the SSJ100 faced some early reliability problems following EIS, but claims these are typical to all new aircraft programmes. SCAC also claims that the aircraft's dispatch reliability is increasing, and is close to matching figures typical of more established aircraft programmes.

SCAC says there has been a continuous improvement plan in place for the SSJ100 since its EIS. This has led to a number of developments, including the introduction of the LR variant in 2014, which subsequently received approval from the European Aviation Safety Agency (EASA) in December 2016.

The Russian Aviation Register of the Interstate Aviation Committee (IAC AR) has also granted a number of new certifications to the SSJ100 since it entered service. These include issuing supplemental type certificates (STCs) that permit the use of vertical navigation (VNAV) functionality in all stages of flight, and the ability to perform flights using area navigation in RNAV 1 and P-RNAV systems. The IAC AR has also granted permission for the SSJ100 to operate from narrow 30-metre-wide runways and to execute automatic landings under CAT IIIA guidelines.

In late 2016 the Russian Federal Air Transport Agency (FATA) issued an Airworthiness Directive (AD) for the SSJ100, relating to a defect detected in a component of the tail stabiliser, which was found during a routine inspection. This led to a number of SSJ100s being temporarily withdrawn from service. SCAC says that it had repaired this issue on all qualifying airframes by 1st February 2017 and that these aircraft have resumed flying. It adds that the defect was the result of 'peculiarities' in

The US represents a limited market for RJs with an MTOW in excess of 86,000lbs and a capacity of more than 76 seats, due to scope clauses in mainline pilot labour agreements. All in-service E195s and CRJ1000s are operated by airlines based outside of the US and Canada. LCCs such as Azul are seen as a potential growth market for RJs at the higher end of the capacity scale.

manufacturing of the component. It emphasises that the issue was not critical in terms of aircraft operational safety, since the component features a multi-level redundant structure and a safety margin that is considerably in excess of operational loads. SCAC is working on improvements to the stabiliser element to prevent similar defects reoccurring.

The order book for the SSJ100 is under review, but Flightglobal's Fleets Analyzer suggests that 56 aircraft are on firm order.

Future development plans include modifying CityJet's SSJ100Bs to allow them to operate from London City airport (LCY). Due to its relatively short runway and steep approach, only a limited number of aircraft types are certified to operate from LCY. According to SCAC, CityJet's SSJ100s will be fully certified for LCY operations by 2018, following enhancements such as software modifications, a new take-off flap position and the installation of winglets.

RJs in development

There are two new large RJ families with outstanding firm orders that are yet to enter service: Embraer's E-Jets E2 family and Mitsubishi Aircraft Corporation's MRJ family.

E-Jets E2 family

Embraer officially launched its next generation E-Jets E2 family at the 2013 Paris Air Show. The E-Jets E2 will feature three models that will use the basic cross-section of the original E-Jets, with new engines, a new wing design, new fourth-generation full fly-by-wire controls and interior and systems improvements.

There will be E2 versions of the E175, E190 and E195, but no next generation development of the smaller E170. The E-Jets E2 aircraft will have the same cross-section and cabin width as its predecessors. The E175 E2 and E195 E2 will be larger than first generation equivalents, with both variants featuring a fuselage stretch. The E190 E2 will have exactly the same fuselage dimensions as the E190. All E-Jet E2 models will have higher weight specifications than E-Jet predecessors.

The E190 E2 and E195 E2 will be classified as one type and share the same type certificate. Unlike the original E-Jets, the E-Jet E2 models will not be available in STD, LR and AR variants. Embraer will instead offer stepped MTOW increases for each variant. Those stated in this analysis are the highest MTOW options that will be available.

The E175 E2 will have a fuselage length of 106ft, 2-inches, making it 2ft, 3-inches longer than the E175. The E175 E2 will accommodate an extra row of seats, pushing capacity up to 80, 88 or 90 seats in typical dual-class, single-class or high-density arrangements. This is four, 10 and two seats more than the E175.

The E175 E2's MTOW and gross structural payload will be up to 98,767lbs and 23,369lbs, while its range with a maximum single-class passenger and baggage payload will be 2,060nm. It could offer 674-1,291lbs of additional payload, and from 140nm less to 310nm more range than an E175, depending on the variant of the original model.

An E190 E2 will have a capacity of up to 97, 106 or 114 seats in dual-class, single-class and high-density arrangements, the same as its predecessor.

The E190 E2's MTOW and gross structural payload will be up to 124,341lbs and 28,836lbs, and its range with a maximum single-class passenger and baggage payload will be 2,850nm. An E190 E2 will therefore offer a minimal payload advantage over an E190, but 400-1,000nm of extra range.

At 136ft, 6-inches, the fuselage of the E195 E2 will be over nine feet longer than that of the original E195. This will allow the next generation aircraft to hold up to three more seat rows than its predecessor. An E195 E2 will accommodate 120, 132 or 146 seats in typical dual-class, single-class or high-density arrangements. This is 20, 14 and 22 more seats than the E195.

The E195 E2's MTOW and gross structural payload will be up to 133,821lbs and 35,605lbs. Range with a maximum single-class passenger and baggage payload will be up to 2,450nm. An E195 E2 will provide nearly 4,900lbs of added payload compared to an E195 and a range advantage of 150-850nm.

Embraer expects the E-Jets E2 family to feature double-digit reductions in fuel burn and maintenance costs compared to first generation E-Jets, thanks to new engines, a new wing design and new fly-by-wire controls. Embraer expects the E175 E2 and E190 E2 to provide 16% reductions in fuel burn per seat compared to the E175 and E190. It expects an even bigger saving from the E195 E2, with which it is targeting a 24% reduction in fuel burn per seat compared to the E195.

All E-Jets E2 family aircraft will be powered by P&W PurePower® PW1000G family engines. The E175 E2 will be equipped with PW1700G series engines, while the E190 E2 and E195 E2 will be powered by the PW1900G series.

The PW1000G family offers superior efficiency. Unlike traditional engine design, the PW1000G family includes a reduction gear linking the fan and low pressure compressor (LPC). The gear allows both to rotate at independent optimum speeds. It subsequently allows the fan to rotate at a slower speed than would be possible if it were turning at the faster rate required of the LPC. The slower speed allows for a large fan diameter, and so higher bypass ratio and increased propulsive efficiency.

The new wing design features a higher aspect ratio than the original E-Jets wing. Coupled with subtle control inputs

SPECIFICATIONS FOR LARGE RJS IN DEVELOPMENT

Aircraft type	MRJ70	E175 E2
Engine type	PW1215G	PW1700G
MTOW (lbs)	STD: 81,240 ER: 85,969 LR: 88,626	98,767
Max structural payload (lbs)	n/a	23,369
Two-class seating	69	80
Standard single class	76	88
Max single class	80	90
Seats abreast (econ)	2+2	2+2
Cargo (cu ft)	644	597
Range (nm)	STD: 1,020 ER: 1,670 LR: 2,020	2,060
Fuselage length (ft)	109ft, 8-inches	106ft, 2-inches
Cabin width (ft)	9ft, 1-inch	9ft
In service	1 year after MRJ90	2021
On order	0 (see notes)	100

Aircraft type	MRJ90	E190 E2	E195 E2
Engine type	PW1217G	PW1900G	PW1900G
MTOW (lbs)	STD: 87,303 ER: 90,378 LR: 94,358	124,341	133,821
Max structural payload (lbs)	n/a	28,836	35,605
Two-class seating	81	97	120
Standard single class	88	106	132
Max single class	92	114	146
Seats abreast (econ)	2+2	2+2	2+2
Cargo (cu ft)	644	761	1,058
Range (nm)	STD: 1,150 ER: 1,550 LR: 2,040	2,850	2,450
Fuselage length (ft)	117ft, 5-inches	118ft, 11-inches	136ft, 6-inches
Cabin width (ft)	9ft, 1-inch	9ft	9ft
In service	2020	2018	2019
On order	233	85	90

Notes:
1). Range based on individual OEM assumptions that could vary by manufacturer- Independent enquiries should be made when comparing types.
2). In-service fleet and order numbers taken from Flightglobal Fleets Analyzer - Accurate as of 16/17th Feb 2017. In-service fleet does not include stored aircraft. Firm orders only.
3). Some MRJ customers have option to convert MRJ90 orders to MRJ70.

permissible via fly-by-wire controls, this should help to reduce drag and fuel burn.

"The E-Jets E2 will provide up to 25% savings in maintenance cost over the first generation E-Jets," claims Silva e Souza. "Some of this will result from new engine technology, but a big contribution will come from the airframe. Scheduled maintenance on the E Jets E2 is expected to cost 50% less per FH, due to longer intervals between structural and systems inspections, more reliable components and the engines spending more time on-wing," he adds. "The initial planned maintenance intervals for the E-Jets E2 are 850FH and 8,500FH for A and C checks, representing 100FH and 1,000FH escalations of current E-Jet intervals."

Like original E-Jets, E-Jets E2 MPD tasks are given individual inspection intervals, giving operators the flexibility to group them into checks as required.

There are 275 E-Jets E2 aircraft on firm order: 100 E175s E2s (all for SkyWest Airlines), 85 E190 E2s and 90 E190 E2s. The largest orders for E190 E2s and E195 E2s will see aircraft destined for Air Costa (25) and Azul (33).

Embraer's decision to update its product was partly driven by a belief that it could produce more efficient aircraft without incurring potential risks and delays associated with developing a clean-sheet design. When the E-Jets E2 programme was launched in 2013 the target EIS dates were 2018 for the E190 E2, 2019 for the E195 E2, and 2020 for the E175 E2. The EIS dates for the two largest family members remain unchanged, but in late 2016 Embraer announced that the E175 E2 will enter service in 2021. "We announced that the E175 E2 EIS has been rescheduled by 12 months," says Silva e Souza. "This was driven by continued interest in the current E175 model in the North American market. EIS dates for the E190 E2 and E195 E2 are unchanged and are scheduled for the first half of 2018 and 2019. Development and certification of the E2 family is progressing as expected. There is no technical reason for the delay to the E175 E2. Scope clause restrictions in the US were part of the consideration."

An explanation of pilot scope clauses in North America and potential impact on RJ fleet planning is addressed in the market trends section of this analysis.

MRJ family

Mitsubishi Aircraft Corporation was formed by Mitsubishi Heavy Industries in 2008 to develop the Mitsubishi Regional Jet (MRJ) family. The MRJ family includes the MRJ70 and MRJ90 series. These aircraft are the only clean-sheet RJ designs in development.

Mitsubishi will offer STD, ER and LR versions of the MRJ70 and MRJ90. It is not disclosing the estimated maximum structural payload for either.

The MRJ70 will have a fuselage length of 109ft, 8-inches and a cabin width of 9ft, 1-inch *(see table, this page)*. It will accommodate up to 69, 76 and 80 seats in typical dual-class, single-class and high-density arrangements and offers four-abreast seating in economy.

The MRJ70's MTOW will vary from 81,240lbs for the MRJ70STD, to 88,626 for the MRJ70LR. Its range with a maximum single-class passenger and baggage payload will vary from 1,020nm for an STD variant to 2,020nm for an MRJ70LR.

The MRJ90 is the largest member of the family. Its fuselage will be the same width as the MRJ70's, but nearly eight feet longer. The longer cabin will allow the MRJ90 to accommodate up to 81, 88 and 92 seats in typical dual-class, single-class and high-density configurations.

The available MTOWs for an MRJ90 will vary from 87,303lbs for an STD variant to 94,358lbs for an LR aircraft. The subsequent range capability for an aircraft with a full single-class passenger and baggage payload will vary from 1,150nm for an MRJ90STD, to 2,040nm for an LR version.

Mitsubishi believes that the MRJ family will demonstrate over a 20% reduction in fuel burn compared to some existing, similar-size RJ types, the result of the MRJ's new P&W PurePower® PW1200G series engines, and high aspect ratio wing and small diameter fuselage that will reduce drag. The MRJ70 will be powered by PW1215G engines, while the MRJ90 will be equipped with the higher thrust PW1217G variant.

Mitsubishi also expects the MRJ family to provide a double-digit reduction in maintenance costs compared to some existing RJs, due to longer intervals between structural inspections, higher component reliability and reduced engine shop visit and LLP replacement costs.

The original maintenance interval

Mitsubishi Aircraft Corporation expects the MRJ series to demonstrate a 20% reduction in fuel burn compared to some existing similar-size RJ types. There are 233 MRJ90s on order. The first aircraft is now due for delivery in mid-2020 following the announcement of a programme delay in January 2017.

targets for the MRJ family were 600FH or 500FC for the equivalent of an A check, and 6,000FH or 5,000FC for the equivalent of a C check. Following a review, the planned intervals have now been extended to 750FH or 700FC for an A check, and to 7,500FH for a C check.

The MPD for the MRJ70 and MRJ90 provides independent inspection intervals for each task, allowing operators to group these into checks according to their own utilisation and requirements.

There are 233 MRJ90s on firm order. There are no orders for MRJ70s although several customers can convert MRJ90 orders to the smaller variant if required.

In January 2017 Mitsubishi announced that the first delivery of the MRJ90 has been delayed until mid-2020. It is expected that the first MRJ70 will be able to enter service in 2021 if required.

"When the MRJ family was launched in 2008, the first delivery was scheduled for December 2013," explains Hideyuki Kamiya, sales and marketing manager at Mitsubishi Aircraft. "The recent announcement represents the fifth schedule delay since the programme was launched and the 2020 delivery target means the first aircraft will be delivered six-and-a-half years later than planned."

The recent delay relates to positioning of certain components and wire harnesses in the avionics bay. "We discovered these issues last autumn," says Kamiya.

"We will be revising the layout of certain system components in the avionics bay and changing the design of the electrical system configuration to address the impact of special risk scenarios in this area of the aircraft, such as water leakage or a terrorist bombing," continues Kamiya, "It is important to note, however, that these changes will not affect aircraft performance, fuel consumption or systems functionality."

Mitsubishi Aircraft has been considering a larger, stretched version of the MRJ family, referred to as the MRJ100X. There are no proposed specifications available for this variant.

Market trends

There are 2,288 large RJs in active passenger service, with a further 258 in storage and 968 on firm order. The main RJ OEMs are positive about future demand prospects.

"Embraer forecasts that there will be a market for 6,400 jets with 70-130 seats in the next 20 years," says Silva e Souza. "That's about $300 billion at list prices, so it is a significant market."

"Bombardier forecasts 5,700 aircraft deliveries for the 60-100 seat segment over the next 20 years, split equally between RJs and turboprops," says Smith. "This segment will continue to be one of the most dynamic in commercial aviation, and it is anticipated that the fleet will more than double in size."

Mark Hughes, executive vice president of corporate finance at regional aircraft lessor Falko, believes that the established RJ OEMs will continue to see more demand for products in the short term. He also suggests that new entrants face a challenge to win market share.

"The CRJ and original E-Jet families remain in demand," says Hughes. "Both Bombardier and Embraer have continued to improve their products, and are being competitive with new aircraft pricing. The products have broad operator bases.

"Embraer's E-Jets E2 family could become the main player in the larger RJ market in the medium- to long-term," adds Hughes. "This depends, however, on whether Embraer can stimulate sufficient demand for used E-Jets to help facilitate current E-Jet operators exiting this product to take E2 variants. The E-Jets E2 must also be priced competitively.

"In contrast, the SSJ100 and MRJ programmes face substantial hurdles in terms of airline acceptance and, more importantly, product support," continues Hughes. "The MRJ has also suffered substantial delays. We do not expect either product to be operated in large numbers in the near term. The MRJ has much better prospects in the longer term, but airlines will be wary of how the global support network will perform."

Large RJ OEMs believe their products can meet various demand requirements, from replacing ageing aircraft to right-sizing capacity or fleet growth. They also believe that large RJs will be used by a broader spread of operators, including low cost carriers (LCCs).

Potential uses

"In the 70-130-seat jet market the replacement of ageing aircraft and new market growth will represent 37% and 63% of demand for new deliveries respectively over the next 20 years," says Silva e Souza. "Some main demand drivers are: direct replacement needs for older 70-130-seat aircraft; replacement of 50- to 70-seat RJs; replacing turboprops on some longer sectors; right-sizing from narrowbodies that provide too much capacity; small narrowbody replacements in the US market; growth into LCCs in Asia and Europe; and regional aviation development in emerging economies."

SCAC believes the SSJ100 is an ideal complement to narrowbody aircraft, noting that it could offer a lower-capacity alternative to A320 or 737 family aircraft during seasonal downturns. It also emphasises how the SSJ100 could work in a hub-and-spoke network.

Potential operators

"The E-Jets are a very flexible tool with a wide range of applications," says Silva e Souza. "63% of the E-Jet fleet is operated by regional carriers, 23% by mainline full-service carriers, and 14% by LCCs. There is a limited number of markets where LCCs can continue to grow using large narrowbodies. Many

Embraer believes its E-Jets E2 family will provide 16-24% reductions in fuel burn per seat compared to its original E-Jet models. It recently rolled out the first E195 E2 which is due to enter service in 2019.

new LCC routes have been removed because they were unable to stimulate enough demand to justify a 180-seat aircraft. I therefore believe the larger E-Jets, and especially the E195 E2, will be used by LCCs to grow into new markets."

"Certain types of airline are showing growth, including LCCs," says Smith. "Our CRJ1000 aircraft can serve this business model, since it has the lowest unit costs in the RJ market."

Regional demand

The level and specific type of demand for large RJs will vary by region. This analysis considers the United States (US) and Canada separately to other global regions, to provide a more accurate idea of differences in potential demand and influencing factors in RJ fleet selection.

United States and Canada

North America, and the US in particular, has historically represented the largest market for RJs. More than half of the active global fleet of passenger-configured RJs is operated by American or Canadian airlines. About 42% of the US and Canadian RJ fleet consists of smaller aircraft, with 50 seats or fewer. Despite this, airlines in the US and Canada still operate 47% of the global large fleet. In addition, 43% of the large RJs on firm order are destined for US or Canadian operators.

Despite these impressive numbers, North America does not represent an entirely open market for prospective large RJ sales. "The RJ market in the US remains dependent on pilot scope agreements," explains Hughes. Most US-based demand for RJs comes from regional operators that fly on behalf of the major full-service carriers: American Airlines (AA), Delta Air Lines (DL) and United Airlines (UA) and to some extent Alaska Airlines (AS). These regional operators are sometimes wholly-owned subsidiaries of a major airline, but many are independent. They typically fly feeder services from smaller communities into large hubs with aircraft operating under the major carrier's regional brands, including American Eagle, Delta Connection or United Express.

In order to provide an element of job security, mainline airline pilot labour agreements feature 'scope clauses'. These are designed to limit the amount of flying that can be performed on the major airline's behalf by non-mainline regional aircraft. Scope clauses can include different detailed restrictions, but some of the most common relate to the MTOW, seat capacity and specific number of regional aircraft that can be operated. Embraer points out that other typical restrictions include limits related to sector length, the amount of block hours flown between hubs, and the hub-to-hub routes served.

"Before the RJ evolution that began in the 1990s, scope restrictions did not really apply to regional flying," explains Jerry Glass, president at labour relations specialist F&H Solutions Group. "Turboprops were not seen as a threat to mainline pilot jobs due to their limited range. The first scope limitations started to appear in the 1990s as 50-seat RJs began to enter the market. These generally restricted the number of 50-seat RJs that could be operated. Scope clauses have been adjusted as technology continued to improve and larger RJs with longer range were introduced," continues Glass. "Initially flying was outsourced to regional operators so that they would provide feeder services to mainline jets at large hubs. Technological improvements mean that the latest RJs have the capacity and range to serve long-thin routes that used to be the exclusive domain of mainline aircraft. They could therefore be seen as more of a threat by mainline pilots' unions, and their arrival has led to the introduction of even more detailed scope limitations, including those that prohibit RJs from operating certain routes."

"Although scope clauses can vary between carriers, there have been general trends in the restrictions relating to the MTOW and seat capacity of RJs that can be operated on behalf of the US majors," says Silva e Souza. "In 2000 the upper limits were an MTOW of 60,000lbs and a capacity of 50 seats. In 2003 this increased to an MTOW of 80,000lbs and a capacity of 70 seats. A further increase to an MTOW of 86,000lbs and a capacity of 76 seats followed in 2006." The MTOW and capacity limits of 86,000lbs and 76 seats remain in place for outsourced AA, DL and UA RJ services today. As well as these upper limits, the scope clauses will also restrict the number of RJs that can be operated with this MTOW and capacity.

The current limitations mean that some of the large RJs in production and in development face limited market potential in North America. The E190, E195 and even the E175 AR do not meet the current scope requirements, while the SSJ100 and baseline and ER variants of the CRJ1000 would also be unable to operate outsourced regional services for the US majors. The only in-production RJs that can operate under current scope limitations are the CRJ700 and CRJ900 series, the E170, STD and ER variants of the E175 and the CRJ1000EL.

The current restrictions would also be a problem for the new E-Jets E2 and MRJ programmes. None of the E-Jets E2 variants could operate for regional airlines on behalf of the US major carriers, and neither could the MRJ90. Only STD and ER variants of the MRJ70 would currently qualify. Even though 81% of the active E175 fleet is operated by US regional carriers, the new E2 variant is unable to follow suit due to its higher MTOW. Embraer freely admits that it has put back the EIS target for the

Over the past three years, the E175 E2 has been outsold by its predecessor, the E175. More than 80% of active E175s are operated by US regional carriers. The E2 variant would not be able to enter service with these carriers on behalf of the US majors under current scope clause limitations, since its MTOW exceeds the 86,000lbs limit.

E175 E2 due to current scope clauses.

Since all of the E175 E2s and nearly two-thirds of the MRJ90s on order are destined for US regional operators, MAC and Embraer are presumably hedging their bets on a relaxation of scope restrictions at the next round of US major pilot labour negotiations. According to Jerry Glass these are due to begin in 2019. There is some disagreement as to whether further scope relaxations are likely in the short to medium term. Those manufacturers with an interest in seeing a relaxation in MTOW and capacity limits are more positive.

"Historically, every time the major airlines see an aircraft that will bring gains, the scope clauses have been relaxed," claims Silva e Souza. "We believe that the E175 E2 will bring better fuel consumption, increased maintenance efficiency, a smaller noise footprint, a reduction in pilot workload and an improvement in passenger comfort."

Others are not convinced there will be significant changes. "We would expect the major airlines to push for an increase in the number of RJs with up to 76 seats that can be flown, rather than attempt to get a higher MTOW or capacity limit," says Hughes. "This would allow for more 50-seat aircraft to be replaced with larger RJs. If there are no changes to the scope restrictions it will severely limit demand in the US for larger RJs. There may be some replacement demand to take out older CRJ700, CRJ900 and E170 aircraft, but this is limited since only about 50 large RJs operating in the US are in excess of 15 years of age."

Doubts concerning the potential relaxation of scope restrictions could explain why the original E175 has outsold its successor by 83 units to zero since the beginning of 2014.

Embraer and Mitsubishi Aircraft remain confident about the prospects for their products regardless of the outcome of the 2019 labour talks. "Embraer is well positioned to capture demand in the US market with the proven E175," says Silva e Souza. "We also see other markets outside the US."

"The MRJ70 is the only next-generation RJ that can accommodate the current scope clause regulations," says Kamiya. "We are working with our customers to find ways to cut the MTOW of the MRJ90 to bring it within current scope clause limits. In addition, we have US-based customers, such as Eastern Air Lines, that are unaffected by scope restrictions."

There could be some large RJ demand in North America from airlines that are not restricted by scope limitations. These include jetBlue, which operates a fleet of E190s (60) and has a further 24 on order, and Eastern Air Lines which has 20 MRJ90s on order.

It is also worth noting that AA has begun operating larger RJs as part of its mainline fleet. It operates 20 E190s. This approach could be a way around scope clauses for the major carriers if no further relaxations are forthcoming. If the other major carriers adopt the same strategy it could lead to an increase in large RJ demand although none of the three majors currently has any large RJs on firm order for their mainline fleets.

Rest of World

Outside the US and Canada the most significant markets for large RJs include Europe, Asia Pacific and in particular China and Australia, Brazil and Mexico.

Scope clause limitations are not as influential outside the US and Canada, so RJ fleet planning strategies in the rest of the world (ROW) have developed differently. In the ROW, RJs with 50 seats or fewer account for only 21% of the active RJ fleet. There is more emphasis on RJs at the higher end of the capacity spectrum, with 78% of active E190s, and all active E195s and CRJ1000s operating with non-US or Canadian airlines.

About 57% of the large RJs on order are destined for ROW operators or leasing companies.

"Outside the US, RJ demand is driven by having the right sized aircraft or operating performance around specific airfields," claims Hughes. "Generally, airlines have been 'upgauging' aircraft on replacement and we would expect to see this at regional level with larger RJs replacing smaller types."

China has been identified as having the potential for large RJ fleet growth.

"Recent announcements in China indicating that new carriers must begin operations with RJs, could significantly boost demand there," says Hughes.

"In China the CRJ family could benefit from the introduction of Rule 96, which requires new Chinese airlines to operate a number of regional aircraft before introducing mainline narrowbodies," explains Smith.

More than 20% of the large RJs on order are destined for Chinese operators, but it should be noted that most of these are for Comac's ARJ21.

SCAC and Mitsubishi Aircraft both believe there are prospects for their products in various ROW regions.

SCAC says its regions of interest are Europe, China, South East Asia and Africa and perhaps opportunities in Europe due to under-served city pairs.

Mitsubishi Aircraft expects 65% of MRJ sales to come from outside North America. "By region we are projecting 35% of sales in North America, 15% in Europe, 25% in the Asia Pacific, and 25% in other regions," explains Kamiya. "In Europe old RJs such as the Fokker 70, Fokker 100 and Avro RJ family will need replacing, so we are promoting the MRJ70 and MRJ90." - *NMP*