Among several new large RJ programmes, the MRJ family and SSJ100 are two aircraft among three or four alternatives of similar seat capacities. The MRJ's & SSJ100's configurations, operating & environmental performance, and maintenance programmes are all examined here.

New 90- to 100-seat RJs assessed: MRJ family & SSJ100

Large regional jets (RJs) and small jetliners are set to be one of the most contested sectors for orders in the coming years, with a number of new airframes entering the market. Bombardier and Embraer are already well established with their CRJ and E-Jet products. Both manufacturers are now working on new projects.

There are additional types on the market, however. In 2011 the Sukhoi SSJ100 entered the market, and by 2015 Mitsubishi plans to have its MRJ family in airline service.

Bombardier is now close to a first flight for its C-series aircraft, while Embraer has announced plans to update the E-Jet family, with new engines among the key changes.

Mitsubishi MRJ

Mitsubishi is new to the world of civil aircraft manufacturing. The Mitsubishi Aircraft Corporation commenced operations on April 1st 2008 with the aim of designing and producing a family of regional airliners. The MRJ series consists of the MRJ70 and the MRJ90.

At the time of writing 165 MRJ90s are on order, with a further 160 on option. There are no firm orders for the MRJ70 at this stage, but some of the orders for the MRJ90 include conversion rights to the smaller aircraft.

Operators with aircraft on order include All Nippon Airways (ANA) in Japan and Trans States Airlines in the US. Another American operator on the order book is the holding company for SkyWest Airlines and Expressjet Airlines, Sky West, which also owns an aircraft leasing company. They concluded a definitive agreement for 100 MRJ90s, in December 2012, with another 100 options.

The MRJ70 and MRJ90 both have a typical four-abreast cabin configuration. The MRJ70 will be able to seat 70-74 passengers in a two-class configuration, or up to 78 in an all-economy layout.

In contrast, the larger MRJ90 will be able to hold 81-85 passengers in a two-class configuration and a maximum of 92 in an all-economy set-up.

Both aircraft will have a cruise speed of Mach 0.74, and a maximum cargo volume of 644 cubic feet. The design has a single cargo compartment at the aft of the fuselage.

There will be three versions of each aircraft available: the standard (STD), extended-range (ER) and long-range (LR) variants. These classifications are determined by the certified maximum take-off weight (MTOW) of the airframe.

The MRJ70STD will have an MTOW of 81,240lbs, while the ER and LR versions will have MTOWs of 85,969lbs and 88,626lbs *(see table, page 16)*.

The MRJ90STD will have an MTOW of 87,303lbs compared to 90,378lbs and 94,358lbs for the ER and LR variants *(see table, page 16)*.

All versions of the MRJ70 and the MRJ90 will have a fuel capacity of 3,200 US gallons (USG). Based on a full passenger payload, this will provide a range of 820 nautical miles (nm) for the MRJ70STD, and 1,470nm and 1,820nm for the ER and LR variants respectively.

The MRJ90STD will have a range of 900nm, compared to 1,290nm and 1,780nm for the ER and LR versions.

The MRJ family will be able to operate from relatively short runways. The MRJ70STD will only need a take-off run of 4,760 feet, while the ER and LR variants will need 5,320 and 5,650 feet.

The MRJ90STD will require 4,890 feet compared to 5,250 and 5,710 feet for the ER and LR versions. These figures are based on the aircraft operating at MTOW from a runway at sea level with International Standard Atmosphere (ISA) conditions.

The MRJ family will not feature an installed or Class 3 electronic flight bag (EFB) system. It will, however, be possible to use standalone Class 1 EFB systems. At this time Mitsubishi does not have its own EFB software, but will consider providing this in the future based on market needs. There are also no current plans for the manufacturer to provide its own electronic technical log (ETL), but operators will be able to install third-party ETL software on their Class 1 EFB devices if they have them.

The MRJ family will feature on-board maintenance computers. "These will provide an aircraft health-monitoring function," says Yugo Fukuhara, marketing director at Mitsubishi Aircraft Corporation. "Their main use will be to collect and analyse failure messages, and search related electronic maintenance manuals. Optional features for the

The MRJ will not feature an installed Class 3 EFB, and there are no plans for the aircraft to have an ETL. The MRJ will, however, feature on-board maintenance computers.

maintenance computer are air-to-ground connectivity, provided by ACARS, and an automatic downlink function for fault messages."

Mitsubishi will provide access to all maintenance manuals through the MRJ web portal. All manuals are based on the latest industry standard S1000D.

Mitsubishi estimates that the MRJ family will give a 20% reduction in fuel burn and therefore a 20% reduction in CO2 emissions over in-service aircraft (excluding the SSJ100) in the RJ class. "This is one of the MRJ's most important features for airline customers," says Fukuhara. Some of this improvement will be due to the family's aerodynamic design and material considerations.

"Multi-disciplinary design optimisation (MDO) technology was applied to the main wing and winglet designs to optimise structural weight and aerodynamic efficiency," explains Fukuhara. "We also focused on weight reduction. About 12% of the structural weight of the MRJ aircraft is made up of composite materials. Carbon fibre reinforced plastic (CFRP) makes up 9% of this, and has been used on the horizontal and vertical tail structure, flight control surfaces and engine nacelles. The remaining 3% consists of glass fibre reinforced plastic (GFRP) which has been used on the radome and belly fairing," adds Fukuhara.

Other aerodynamic considerations include the MRJ's higher aspect ratio wing than current in-service RJs (excluding the SSJ100). "We also have a more efficient fuselage diameter," claims Fukuhara. "With the configuration of an aft rather than a belly cargo compartment we do not need as much area below the passenger cabin. The underfloor space is only required for aircraft systems."

Improvements in fuel burn and CO2 emissions will also directly result from Mitsubishi's choice of engine for the MRJ: Pratt and Whitney's PW1200G Pure Power geared turbofans.

PW1200G

Mitsubishi's need for a powerplant for the MRJ family led to it becoming the launch customer for Pratt and Whitney's PW1000G family of Geared Turbofan™ engines. This series will also now power the Bombardier C-Series, Airbus A320neo family, Irkut's MC-21 and the next generation of Embraer E-Jets.

The MRJ family will be powered by the PW1200G engine. These engines have a fan diameter of 56 inches and a bypass ratio of 9:1. The MRJ70 will be fitted with PW1215Gs, providing an engine thrust of 15,600lbs. The MRJ90 will fly with PW1217Gs, rated at 17,600lbs thrust.

These powerplants are expected to help deliver the 20% fuel burn savings over current RJs, as well as reduce annual CO2 emissions by up to 4,000 tonnes in comparison with similar in-service aircraft.

The MRJ70 and MRJ90 are also expected to demonstrate NOx margins 50% below current CAEP VI standards. It is estimated that the MRJ70 will operate at a noise margin of 19 EPNdB below current stage IV requirements. The MRJ90 is expected to be 17 EPNDb below stage IV levels.

The main concept behind the Pure Power Geared Turbofan engines is an improvement in propulsive efficiency, achieved by allowing the low pressure compressor (LPC) and fan to operate at their optimum revolutions, rather than being forced to turn at the same number of revolutions because they are mounted on the same shaft.

The ability to operate at different revolutionary speeds is due to a gearbox between the LPC and the fan. The LPT drives the LPC and fan, but because the gearbox allows the LPC and fan to spin at different speeds, the LPT and LPC can therefore turn at higher revolutions and so optimise their efficiency.

This higher revolutionary speed allows the LPC and LPT to generate the same amount of pressure with fewer stages. Fewer stages means fewer airfoils and potentially lower maintenance costs.

The gearing system also allows the fan to rotate at a lower revolutionary speed. The knock-on effect of this is ultimately to allow a wider fan diameter. "A slower fan speed leads to a lower fan pressure ratio, a lower exit velocity, and a reduction of around 75% in the noise footprint of the aircraft compared current generation types," explains Jim Speich, commercial engines marketing director at Pratt and Whitney. The wider fan diameter leads to increased airflow, a higher bypass ratio and improved propulsive efficiency. It can also have noise reduction benefits. Lower fuel burn is a direct result of increased propulsive efficiency and a reduced exit speed.

"The gear system will account for less than 2% of the engine maintenance costs, has no life limited parts (LLPs) and does not require an on-wing inspection," says Speich. "It will only require inspection on every second engine shop visit or overhaul." Pratt and Whitney expects the PW1200G series to be certified in 2014.

Sukhoi Superjet 100

In 2000 Sukhoi Civil Aircraft Company was formed with the aim of developing a new regional aircraft. The result is the SSJ100. The company is 75% minus one share owned by Sukhoi Holding and 25% plus one share owned by Alenia Aermacchi, a Finmeccanica company.

In 2007 these two partners established a strategic partnership and formed a joint venture (JV) called SuperJet International. Based in Italy, this JV promotes and sells the SSJ100 in mature markets across Europe, North

MRJ & SSJ100 SERIES SPECIFICATIONS

	MRJ Family MRJ70	MRJ90	SSJ100/95
Two Class Seating	70-74	81-85	87
Maximum Seating	78	92	98
Economy Layout	2+2	2+2	2+3
Cargo Volume (cu. Ft)	644	644	768.6
Engine Type	PW1215G	PW1217G	B: SaM146: 1S17 LR: SaM146: 1S18
Engine Thrust (lbs)	15,600	17,600	B: 17,300 LR: 17,800
Fan Diameter (Inches)	56	56	48
Bypass Ratio	9:1	9:1	4.4:1
MTOW (lbs)	STD: 81,240 ER: 85,969 LR: 88,626	STD: 87,303 ER: 90,378 LR: 94,358	B: 101,150 LR: 109,109
MLW (lbs)	79,807	83,776	90,390
MZFW (lbs)	74,957	79,697	88,185
Fuel Capacity (USG)	3,200	3,200	4,175
Range (nm)	STD: 820 ER: 1,470 LR: 1,820	STD: 900 ER: 1,290 LR: 1,780	B: 1,645 LR: 2,470
Takeoff field Length (ft)	STD: 4,760 ER: 5,320 LR: 5,650	STD: 4,890 ER: 5,250 LR: 5,710	B: 5,679 LR: 6,732
Landing field length (ft)	4,700	4,860	5,348
Cruise speed (Mach)	0.74	0.74	0.78
On Board MTCE Computer	Yes	Yes	Yes
EFB	Class 1 (Option)	Class 1 (Option)	Class 2 (Option)
Fuel burn savings	20%	20%	10%
NOx margin to CAEP VI	50%	50%	20%
Noise margin to Stage IV (EPNdB)	19	17	5
CO_2 savings (tonnes per year)	4,000 per a/c	4,000 per a/c	1500+ per a/c
Entry in to service	2016	2015	B: 2011 LR: 2014
Firm order backlog	0	165	167
Options	0	160	52

Mitsubishi Notes: Range based on full pax payload, Take-off length based on MTOW, Sea Level, ISA, Landing length based on MLW, Dry conditions, Fuel burn and CO_2 comparisons based on comparative in service aircraft (excluding SSJ100). Some MRJ90 orders have conversion option to MRJ70.

Sukhoi SuperJet Notes: Range based on 98 pax with bags @ 220lbs, LRC, ISA, zero wind, typical reserve policy. Take-off length based on MTOW, Landing length based on MLW, Fuel burn and CO_2 comparisons based on comparative in service aircraft. CO_2 save based on 1800FC per year with avg 1.3FH per FC.

and South America, Africa, Japan and Oceania.

SuperJet International is the completion and delivery centre for western customers. It is also responsible for worldwide after-sales support and training.

Like Mitsubishi, Sukhoi SuperJet originally planned to introduce two variants of its RJ family: the SSJ100/75 and the SSJ100/95. Detailed design work has been completed for the SSJ100/75, but its production launch is now frozen.

There are currently 11 SSJ100/95 family aircraft in active passenger service, most of which are operated by Aeroflot. The first SSJ100/95 entered service in April 2011 with Armavia. Aeroflot received its first aircraft in June of the same year. The current order backlog stands at 167 aircraft (with 52 on option) with Aeroflot, Kartika Airlines, UTair and Pearl Aircraft Corporation among the customers. There are two versions of the SSJ100/95: the basic (B), which is already in operation; and long-range (LR), which is expected to enter service in 2014.

Both versions of the SSJ100/95 have a typical two-plus-three, five-abreast economy cabin configuration, allowing for a maximum capacity of 98 passengers. In a two-class configuration the aircraft can hold up to 87 seats.

The aircraft's cruise speed is Mach 0.78, and it provides a cargo volume of 768.6 cubic feet.

The SSJ100/95B has a certified MTOW of 101,150lbs compared to 109,019lbs for the LR model. Both variants have a fuel capacity of 4,175 USG. This provides a maximum range of 1,645nm for the SSJ100/95B, and 2,470nm for the LR aircraft. These range assumptions are based on a 98-passenger load, with bags weighing 220lbs, operating at long-range cruise (LRC) in ISA conditions, zero wind and typical international fuel reserve fuel policy.

The take-off performance of the aircraft differs according to the model. Based on an MTOW assumption, the SSJ100/95B requires a 5,679 foot take-off run. The LR version requires a longer runway with a 6,732 foot take-off run.

The SSJ100/95 family of aircraft are equipped with an on-board maintenance computer known as the Central Maintenance System (CMS). The CMS is manufactured by Thales, and provides a human interface to perform maintenance tasks and troubleshooting actions for the aircraft. Thales highlights the system's main functions as detecting failures in aircraft systems, logging fault data and identifying Line Replaceable Units (LRUs) that need replacing. It also has a test capability to confirm failures and can support downloading maintenance reports via ACARS.

"The main component of the CMS is basically the maintenance access terminal (MAT)," says Sukhoi Superjet. "The MAT is based on a Class 2 EFB device dedicated to maintenance usage and comprises a display, a computer and a display docking station. The MAT display terminal is in the flightdeck."

There are three additional connection ports in the aircraft external avionics bay to provide access for portable maintenance access terminals (PMAT). This allows up to four mechanics to work simultaneously on different maintenance tasks, providing significant savings in aircraft maintenance ground time.

"The CMS does not currently offer all the functions of an ETL. Such functions may be the next evolutionary step of the system," says Christophe Fresnel, Superjet 100 program director at Thales.

The SSJ100/95's optional EFB solution uses the same display as the CMS, and is therefore not portable. Operators do have the option to run third-party software on the EFB.

Sukhoi supplies operational and maintenance manuals and data on-line, on CD-ROM in PDF format and in a paper format. On the operational side this includes the flight crew operating

The SSJ100 has a central maintenance system to provide a human interface to perform maintenance tasks and troubleshooting actions.

manual (FCOM), aeroplane flight manual (AFM), master minimum equipment list (MMEL), weight and balance manual (WBM) and operating performance manual (OPM). Some of those included for maintenance purposes are the aircraft maintenance manual (AMM), aircraft illustrated parts catalogue (AIPC) and the maintenance planning document (MPD).

Sukhoi Superjet claims the SSJ100 family demonstrates a 10% saving in fuel consumption compared to competing aircraft currently in service. It also claims a CO2 saving of 11% per trip when compared to the competition.

Some savings are due to the aircraft's weight and aerodynamic design. Sukhoi says that a five-abreast configuration for a 100-seat jet optimises the weight of the airframe and systems. Composite materials have been used for mobile surfaces, the belly fairing and radome, and internal parts like the floor panels. Sukhoi claims that the SSJ100 features the highest aerodynamic efficiency of its class, due to several factors, including a new supercritical wing profile specifically designed for this aircraft. The SSJ100 is also the first airliner whose engine and airframe have been designed together to optimise performance. The aircraft are powered by SaM146 engines.

SaM146

The SaM146 engine family is a product of PowerJet, a joint venture between Snecma of France and NPO Saturn of Russia. Specifically designed for the SSJ100 family, the engines are only available for this aircraft.

This engine family has a fan diameter of 48 inches and a bypass ratio of 4.4:1. The SSJ100/95B will operate with SaM146 1S17s, rated at 17,300lbs of thrust. The LR variant will be powered by SaM146 1S18s, rated at 17,800lbs thrust.

These powerplants will provide the SSJ100's claimed fuel burn savings of 10%, together with CO2 savings of more than 1,500 tonnes per year in comparison to competing in-service aircraft. The SaM146 engine family is also claimed to demonstrate NOx margins 20% below current CAEP VI standards, and has a noise margin of 5EPNdB below Stage IV requirements.

According to PowerJet, the main contributions to the engine's fuel burn performance are its aerodynamic design, weight reductions, optimised fan blades, and highly efficient combustion chamber.

PowerJet has tried to optimise aerodynamic efficiency by integrating the design of the full propulsion system, including the engines, nacelles and thrust reversers. It has also minimised weight by including composite materials in 42% of the nacelle. Fuel burn is also improved by optimising the way fuel and air are mixed to ensure maximum fuel burn takes place inside the combustion chamber. Smaller titanium fan blades with an optimised wide-cords sweep also contribute to increased efficiency.

Environmental and noise emissions are both improved by the engine's long duct mixed-flow nozzle design. Sukhoi Superjet hopes to improve the noise margin performance of the SSJ100 with the LR variant.

An important aspect of the engine's design relates to optimising maintenance procedures and reducing maintenance costs. The engine has fewer stages than its competitors. This includes a single-stage high pressure turbine (HPT) and a six-stage high pressure compressor (HPC). This reduces the number of parts, and so should reduce maintenance costs.

The line replaceable units (LRUs) have been designed to be changed within 20 minutes, and the engine and nacelle in less than two hours. Following two years' operation, engine reliability feedback has been positive with a despatch reliability of 99.8%.

Maintenance programme

The MRJ series has an MSG-3 maintenance programme. The initial target interval for A-checks is 600 flight hours (FH) or 500 flight cycles (FC), whichever comes first. The initial target for C-checks is an interval of 6,000FH or 5,000FC. Both of these targets will need to be approved at the time of awarding the aircraft their type certificates.

Mitsubishi plans to have a structural check interval of eight years for aluminium structures on its RJs. The interval for composite structures is to be 12 years. This will result in out-of-phase structural checks after the first ones have been performed.

The manufacturer will accumulate field data after the aircraft enter service and based on this, aims to extend check intervals by up to 20%.

The SSJ100 family's maintenance programme complies with the latest MSG-3 guidelines. The A-check interval is 750FH or 100 days, whichever comes first. C-checks must be carried out every 7,500FH, 6,000FC or two years, and heavy 4C maintenance tasks every 30,000FH, 24,000FC or eight years.

Summary

Both Mitsubishi and Sukhoi Superjet have designed their new RJs to demonstrate a marked improvement in terms of fuel burn, environmental impact and maintenance costs and procedures. They have focused on aerodynamic design, weight-saving methods that include the use of composite materials and advanced on-board maintenance systems. Most significantly both aircraft programmes will be the launch customer for newly designed powerplants. AC

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