AEI expects to receive STCs for its CRJ100/200 SF freighter conversion in 2016. It could be suited to long routes with thin demand, but will face competition from large turboprops. The CRJ 100/200 SF's potential market is examined here, along with its payload and acquisition costs.

The CRJ100/200 SF freighter conversion programme

In February 2013 Aeronautical Engineers Inc (AEI) launched a passenger-to-freighter conversion programme for Bombardier CRJ100 and CRJ200 series regional jets (RJs).

Following several years of design and development work, AEI expects to receive supplemental type certificates (STCs) for its CRJ100/-200 conversion from the Federal Aviation Administration (FAA) and the European Aviation Safety Agency (EASA) in 2016. It expects to begin full-scale production in December 2016.

The potential market for CRJ100 and 200 freighters is assessed here, together with their likely on-ramp costs and payload performance.

CRJ100/200 SF

AEI is a Bombardier-licensed third-party STC provider. Airframes modified to freighter status under AEI's conversion programme will be designated CRJ100 or CRJ200 special freighter (SF) aircraft.

The conversion will involve the installation of a Class E main deck cargo compartment, and a large 94-inch X 70-inch cargo door on the left side of the fuselage, forward of the wing. Cabin windows will be replaced with aluminium window plugs and a 9G rigid cargo and smoke barrier will be installed. An Ancra International cargo loading system will be included in the standard conversion price.

AEI's conversion will be certified for both CRJ100 and CRJ200 Series aircraft; these share the same fuselage structure and dimensions. Converted aircraft will therefore offer the same cargo volume and loading configurations.

Containers and pallets

A CRJ100/200 SF will be capable of accommodating up to eight unit load devices (ULDs) or pallets with base dimensions of 61.5-inches X 88-inches on its main deck. AEI claims that there is also the option to configure aircraft with eight 62-inch X 88-inch main deck loading positions. When a CRJ100/200 SF is loaded with eight containers or pallets there is no additional volume available for bulk cargo.

There are no existing containers and pallets optimised for the main deck fuselage dimensions and internal contour of a CRJ100/200 SF. There are, however, a number of proposed solutions tailored towards the CRJ100/200 SF's eight loading positions. These include the ASZ and LSY containers, and the PSA pallet.

An ASZ container would have base dimensions of 88-inches X 61.5-inches and a height of 67.9-inches. It would have an internal volume of 169.5 cubic feet (cu ft). A CRJ100/200 SF loaded with eight ASZ ULDs would thus have a containerised cargo volume of 1,356 cu ft *(see table, page 77)*.

A LSY container would also have base dimensions of 88-inches X 61.5-inches, but a lower height of 63.8-inches. It would therefore offer a smaller internal volume of about 155.4 cu ft. This container was specially developed for the CRJ100/200 SF, but is also designed for use on other freighter types.

A CRJ100/200 SF could be loaded with eight LSY ULDs in a single row all facing forward. This would offer a containerised cargo volume of 1,243 cu ft *(see table, page 77)*.

LSY containers could also be used on the main deck of 737 and 757 freighters if loaded back-to-back in a double row arrangement. The LSY container could also fit in an A300-600F if loaded back-to-back with one container facing forward and one facing aft. Its reduced height would also allow it to be accommodated in the underfloor compartment of widebodies. LSY containers could appeal to potential CRJ100/200 SF operators that need to interline between different freighter types.

A PSA pallet would have base dimensions of 88-inches X 61.5-inches, and be capable of holding up to 225 cu ft of cargo. A CRJ100/200 SF loaded with eight PSA pallets would offer a palletised freight volume of about 1,800 cu ft *(see table, page 77)*.

Weight specifications

The CRJ100's and CRJ200's identical fuselage means that both aircraft have the same certified weight limitations.

There are two main CRJ100 and CRJ200 variants: the extended-range (ER) and long-range (LR) derivatives.

CRJ100 and CRJ200 ER aircraft have a maximum take-off weight (MTOW) of up to 51,000lbs and a maximum zero fuel weight (MZFW) of up to 44,000lbs *(see table, page 74)*. CRJ100 and CRJ200 LR aircraft maintain the same MZFW of 44,000lbs, but have a higher MTOW of up to 53,000lbs. This allows them to carry more fuel and provide additional range.

The primary difference between the

CRJ100/200 SF BASIC SPECIFICATIONS

Aircraft	CRJ100 SF ER	CRJ100 SF LR	CRJ200 SF ER	CRJ200 SF LR
Engine	CF34-3A1	CF34-3A1	CF34-3B1	CF34-3B1
MTOW (lbs)	Up to 51,000	Up to 53,000	Up to 51,000	Up to 53,000
MZFW (lbs)	Up to 44,000	Up to 44,000	Up to 44,000	Up to 44,000
Max structural payload (lbs)	Up to 14,870	Up to 14,870	Up to 14,840	Up to 14,840

CR100 and CRJ200 is the engine variant they are quipped with. The CRJ100 operates with CF34-3A1 powerplants, and the CRJ200 with later model CF34-3B1 engines.

A pair of CF34-3A1s is about 30lbs lighter than a pair of CF34-3B1s. One consequence of this is that the CRJ100 has a marginally lower operating empty weight (OEW) than a CRJ200. This means a CRJ100 SF would have an equal-sized gross structural payload advantage over a CRJ200 SF.

AEI claims that a CRJ200 SF would have a gross structural payload of about 14,840lbs *(see table, this page)*. It can be assumed that a CRJ100 SF would have a gross structural payload of 14,870lbs. A CRJ100/200 SF would therefore offer a gross structural payload of about 6.7 metric tonnes (t).

CRJ100/200 differences

CF34-3B1 engines give the CRJ200 a number of performance advantages over the CF34-3A1-powered CRJ100. These include an increased take-off flat rating, improved specific fuel consumption in cruise, and improved climb thrust.

The CRJ200 also has better hot-and-high field performance than the CRJ100 due to increased airflow in the CF34-3B1's compressor section and that engine's improved clearances, reduced cooling requirements and durability improvements in the high-pressure turbine section. The CF34-3B1 also features improved clearances, reduced leakage and durability improvements in the low pressure turbine section.

The CRJ100 and CRJ200 have the same type certificate. The engine type is the only factor that specifies which variant an airframe is certified as. CF34-3A1 and CF34-3B1 engines are interchangeable between airframes. An aircraft previously certified as a CRJ100 because of its CF34-3A1 powerplants will be certified as a CRJ200 if these are replaced with CF34-3B1 engines.

In addition, no structural changes are required to change between ER and LR variants of the CRJ100 and CRJ200.

RJ freighter alternatives

The CRJ100/200 SF is the only conventional, large cargo door conversion programme under development in the RJ market.

An alternative freighter variant of the CRJ100/200 is already in service. Cascade Aerospace in Canada provides CRJ100/200 Package Freighter (PF) kits which can be installed by a third party. These kits include the airworthiness certification, technical publications, parts, and modification instructions required to convert passenger-configured CRJ100 or CRJ200 aircraft into Class E package freighters.

The CRJ100/200 PF conversion involves the installation of a full-length Class E cargo compartment, designed to accommodate package freight and/or containers. Unlike the CRJ100/200 SF, the PF modification does not include the installation of a large cargo door. The size of freight and/or containers that can be loaded is therefore limited by the dimensions of the main passenger entry and aft cargo doors.

The Cascade Aerospace CRJ100/200 PF kit offers a bulk cargo volume of 1,765 cu ft and a gross structural payload of about 15,000lbs. The conversion can be completed in 24 working days.

There are currently two CRJ100 PF and four CRJ200 PF aircraft in service, with a further two CRJ200 PFs in storage.

AEI does not believe that the CRJ100/200 PF solution will compete in the same market as AEI's CRJ100/200 SF product. "The STC for the CRJ100/200 PF has been in place for more than five years and fewer than 10 units have been sold," says Robert Convey, senior vice president of sales and marketing at AEI. "We have 40 orders and I believe that we will sell in excess of 200 CRJ100/200 SF conversions. Operators want the large cargo door."

Bombardier believes that there is room in the market for both products. "The CRJ100/200 PF can be hand-loaded quickly and makes sense for loose bulk freight," explains Delio Petohleb, director of asset management group sales, Bombardier Commercial Aircraft. "The CR100/200 SF is more suited for transporting large heavy equipment due to its large cargo door. It can also accommodate containerised freight, which offers operators the potential for interlining."

The only other active RJ freighters are BAE 146-100, -200 and -300QTs. These are unlikely to be considered as alternatives to the CRJ100/200 SF. There are 14 BAE 146 freighters in service, but their numbers have halved over the past five years. In addition, the BAE 146 and CRJ100/200 SF offer different payload options. A BAE 146-200QT and -300QT provide a maximum gross payload of about 25,000lbs and 27,400lbs. This is almost double the gross payload offered by the CRJ100/200 SF in the case of the BAE 146-300QT.

Turboprop competition

The main competition for the CRJ100/200 SF is likely to come from turboprop freighters, since they offer the closest match in terms of gross payload capability. The strongest competition is likely to come from turboprop freighters with large cargo doors.

Many turboprop freighters operate as bulk freighters. This means cargo is bulk loaded through existing passenger or cargo doors. Despite this, ATR 42s, Fokker 50s, BAE ATPs and ATR 72s have all undergone passenger-to-freighter conversions that involve the installation of a large cargo door.

Only one ATR 42 has undergone a large cargo door conversion. This suggests there is little demand for this product, and that it is unlikely to be a significant competitor to the CRJ100/200 SF.

Fokker 50, ATP and ATR 72-200/-210 freighters that have undergone large cargo door conversions provide gross structural payloads of 15,600lbs, 17,020-18,217lbs and 17,750lbs. The Fokker 50, ATP and ATR 72 freighters would therefore offer about 750lbs, 2,200-3,350lbs, and 2,900lbs more gross payload than the CRJ100/200 SF.

Most ATR 72s that been converted to freighters so far have been -200/-210 series aircraft, but more -500 series models are likely to be converted in the future. These would offer a slightly higher gross structural payload than a -200/-210 series aircraft. The latest ATR72-600 series will not approach typical conversion feedstock age for many years.

Most passenger-to-freighter conversions take place when the feedstock aircraft is 15-20 years old. This

CRJ AND ATR CONTAINER & PALLET SPECIFICATION ASSUMPTIONS

	Volume (cu ft)	Tare weight (lbs)
Containers		
ASZ	169.5	225
LSY	155.4	298
LD3	154	220
88" x 108"	301	330
ABZ	353.2	330
Pallets		
PSA	225	101
88" x 108"	301	181

is when market values generally fall to a level that makes the conversion economically viable.

When the CRJ100/200 SF conversion programme ramps up to the production phase in December 2016, the passenger-configured fleet of ATR 72s will include 92 aircraft that fall within the typical freighter feedstock age range. This will include 18 ATR 72-200/-210s and 74 ATR 72-500s.

In contrast, there will only be six Fokker 50s of 15-20 years old and no ATPs. Only 61 ATPs were ever built, and just nine remain in a passenger configuration. The youngest of these airframes is already 24 years old, so future conversion options are limited.

The feedstock situation suggests that ATR 72 freighters with large cargo doors will be the main alternative to CRJ100/200 SFs in the near- to medium-term.

Swiss-based IPR Conversion Ltd is part of IPR Invest. It acquired the STCs for passenger-to-freighter conversions of ATR aircraft from Alenia Aermacchi in July 2015.

There are two conversion alternatives for ATR 42 and 72 aircraft. The first converts the aircraft into a bulk freighter and uses the existing cargo door. This is known as the structural tube conversion. The second option involves the installation of a large cargo door (LCD), and is known as the LCD and structural tube conversion.

IPR is marketing both types of conversion and has already delivered its first converted bulk freighter. Several other organisations provide bulk freighter conversions for ATR aircraft, but IPR Conversions holds the only STC for LCD conversions.

Most ATR aircraft converted to freighter status have received the bulk, structural tube modification, but IPR is seeing a rise in demand for LCD conversions.

"Alenia only performed 11 LCD conversions in 15 years, and 10 of these were for ATR 72s," explains Hülya Utli, general manager at IPR Conversions. "We have already booked 10 conversion slots for ATR 72-200/-210 LCD freighters in the eight months since we took ownership of the STCs. We also expect to receive an order for the LCD conversion of an ATR 72-500 in the coming weeks."

An ATR 72 LCD freighter can accommodate up to seven LD-3 containers or five ABZ, or 88-inch X 108-inch containers plus bulk cargo. It can also accommodate five 88-inch X 108-inch pallets, plus additional bulk cargo. These containers and pallets are all available, with the exception of the ABZ ULD, which is currently in development.

Payload performance

A freighter's net structural payload, maximum packing density and volumetric capacity at different packing densities are indicators of its payload capacity.

The net structural payload is the actual weight of revenue-earning cargo that can be carried, and is calculated by subtracting the tare weight of containers or pallets from the aircraft's gross structural payload.

The maximum packing density reveals the optimum density at which freight can be loaded to make full use of the available payload and volume. It is calculated by dividing the net structural payload by the available volume.

The volumetric payload reveals the actual cargo payload that can be carried at a given packing density.

The net structural payload, maximum packing density and volumetric capacity could vary depending on whether the aircraft is used for express package or general freight operations.

Express package or integrator operations generally revolve around hub-and-spoke networks and the containerised transport of small packages and parcels at packing densities of 6.5-7.0lbs per cu ft. Aircraft configured for express package operations often 'cube' or 'bulk' out because of these relatively low packing densities. This occurs when the available volume is used up before the full net structural payload is reached.

General freight operations tend to involve the carriage of larger, bulkier items on pallets, and on point-to-point markets. Typical packing densities might start at about 9.0lbs per cu ft. Aircraft configured for general freight operations may 'gross' out. This takes place when the net structural payload is reached before the available volume has been fully occupied.

In some cases an aircraft may have a higher net structural payload and maximum packing density when configured for general freight operations, since pallets have lower tare weights than containers.

The potential net structural payloads, maximum packing densities and volumetric capacities of the CRJ100 SF and CRJ 200 SF have been analysed in containerised and palletised configurations at packing densities of 7.0lbs and 9.0lbs per cu ft, to show their payload capacity in typical express package and general freight configurations.

They are compared to ATR 72 LCD freighters, since this aircraft represents the likeliest near-term alternative solution to the CRJ100/200 SF.

The specifications used here are for ATR 72-200/-210 series aircraft. ATR 72-500s are increasingly likely to be converted in the future. These would likely offer slightly higher payload capacity.

An ATR 72 LCD freighter can accommodate up to 470 cu ft of bulk cargo in the rear of the cabin, in addition to main deck containers or pallets. The aircraft's resulting cargo volume, maximum packing density and volumetric capacity will vary depending on whether this bulk volume is included in the aircraft's total cargo volume. The use of this additional bulk cargo volume may vary by operator. This analysis accounts for both scenarios to provide a comprehensive comparison.

The volume and tare weight assumptions for the ULDs and pallets used in this analysis have been summarised *(see table, this page)*. The specifications for the ASZ, LSY and ABZ containers and PSA pallets are based on technical proposals, since they are not currently in use. The volume and tare weights of ULDs and pallets can vary by manufacturer. The volume of freight that can be accommodated by individual pallets can also vary with different fuselage contours.

The gross structural payload figures are based on estimated operating empty weights (OEWs). In reality OEW will vary by individual aircraft.

CRJ100/200 SF & ATR 72LCD FREIGHTER PAYLOAD SPECIFICATIONS

Configuration	CRJ100 SF ER	CRJ100 SF LR	CRJ200 SF ER	CRJ200 SF LR	ATR 72 -200/-210 LCD F	ATR 72 -200/-210 LCD F
Containers	8 ASZ	8 ASZ	8 ASZ	8 ASZ	7 LD3 plus bulk	7 x LD3 exc bulk
Gross Payload (lbs)	14,870	14,870	14,840	14,840	17,750	17,750
Total volume (cu ft)	1,356	1,356	1,356	1,356	1,548	1,078
Total tare weight (lbs)	1,800	1,800	1,800	1,800	1,540	1,540
Net structural payload (lbs)	13,070	13,070	13,040	13,040	16,210	16,210
Max packing density (lbs/cu ft)	9.64	9.64	9.62	9.62	10.47	15.04
Volumetric payload @ 7.olbs/cu ft	9,492	9,492	9,492	9,492	10,836	7,546
Volumetric payload @ 9.olbs/cu ft	12,204	12,204	12,204	12,204	13,932	9,702

Configuration	CRJ100 SF ER	CRJ100 SF LR	CRJ200 SF ER	CRJ200 SF LR	ATR 72 -200/-210 LCD F	ATR 72 -200/-210 LCD F
Containers	8 LSY	8 LSY	8 LSY	8 LSY	5 (88"x108') plus bulk	5 (88"x108') exc bulk
Gross Payload (lbs)	14,870	14,870	14,840	14,840	17,750	17,750
Total volume (cu ft)	1,243	1,243	1,243	1,243	1,975	1,505
Total tare weight (lbs)	2,384	2,384	2,384	2,384	1,650	1,650
Net structural payload (lbs)	12,486	12,486	12,456	12,456	16,100	16,100
Max packing density (lbs/cu ft)	10.04	10.04	10.02	10.02	8.15	10.70
Volumetric payload @ 7.olbs/cu ft	8,702	8,702	8,702	8,702	13,825	10,535
Volumetric payload @ 9.olbs/cu ft	11,189	11,189	11,189	11,189	16,100	13,545

Configuration	ATR 72 -200/-210 LCD F	ATR 72 -200/-210 LCD F
Containers	5 ABZ plus bulk	5 ABZ exc bulk
Gross Payload (lbs)	17,750	17,750
Total volume (cu ft)	2,236	1,766
Total tare weight (lbs)	1,650	1,650
Net structural payload (lbs)	16,100	16,100
Max packing density (lbs/cu ft)	7.20	9.12
Volumetric payload @ 7.olbs/cu ft	15,652	12,362
Volumetric payload @ 9.olbs/cu ft	16,100	15,894

Configuration	CRJ100 SF ER	CRJ100 SF LR	CRJ200 SF ER	CRJ200 SF LR	ATR 72 -200/-210 LCD F	ATR 72 -200/-210 LCD F
Pallets	8 PSA	8 PSA	8 PSA	8 PSA	5 (88"x108') plus bulk	5 (88"x108') exc bulk
Gross Payload (lbs)	14,870	14,870	14,840	14,840	17,750	17,750
Total volume (cu ft)	1,800	1,800	1,800	1,800	1,975	1,505
Total tare weight (lbs)	808	808	808	808	905	905
Net structural payload (lbs)	14,062	14,062	14,032	14,032	16,845	16,845
Max packing density (lbs/cu ft)	7.81	7.81	7.80	7.80	8.53	11.19
Volumetric payload @ 7.olbs/cu ft	12,600	12,600	12,600	12,600	13,825	10,535
Volumetric payload @ 9.olbs/cu ft	14,062	14,062	14,032	14,032	16,845	13,545

Notes:
1). Gross payload based on estimated OEWs. OEW will vary by individual aircraft.
2). ATR 72-200/-210 figures assume MZFW of 44,092lbs OEW of 25,657lbs CLS weight of 685lbs and bulk cargo volume of 470 cu ft.

Net structural payload

It is proposed that the CRJ100/200 SF will accommodate up to eight ASZ or LSY containers or eight PSA pallets.

The CRJ200 SF would have a net structural payload of 13,040lbs or 12,456lbs when loaded with ASZ or LSY ULDs *(see table, this page)*. The CRJ100 SF would have a marginally higher net structural payload of 13,070lbs or 12,486lbs due to its lighter engines.

An ATR 72 LCD freighter can accommodate up to seven LD-3 containers, or five 88-inch X 108-inch, or ABZ ULDs. The net structural payload of an ATR 72-200/-210 LCD freighter varies from 16,100-16,210lbs depending on the container configuration *(see table, this page)*. An ATR 72-200/-210 LCD freighter would therefore offer a net structural payload advantage of 3,030-3,784lbs when compared to a CRJ100/200 SF in a containerised scenario.

The CRJ200 SF would have maximum packing densities of 9.62 and 10.02lbs per cu ft (lbs/cu ft) when loaded with ASZ or LSY containers. The CRJ100 SF would have marginally higher maximum packing densities of 9.64 and 10.04lbs/cu ft when loaded with ASZ or LSY ULDs.

The maximum packing density of an ATR 72-200/-210 LCD freighter loaded with containers will vary depending on the ULD type, and on whether the bulk cargo volume is accounted for. It could vary from 7.20-15.04lbs/cu ft *(see table, this page)*.

The CRJ200 SF would have a net structural payload of 14,032lbs when configured with PSA pallets. The CRJ100 SF would have a marginally higher net structural payload of 14,062lbs.

The net structural payload of an ATR 72-200/-210 LCD freighter loaded with 88-inch X 108-inch pallets would be 16,845lbs.

In a palletised configuration, an ATR 72-200/-210 LCD freighter would have a

The CRJ 100/200 SF is the only large cargo door freight conversion programme under development for an RJ aircraft. AEI expects to receive STCs for its conversion from the FAA and EASA in 2016.

net structural payload advantage of about 2,800lbs compared to a CRJ100/200 SF.

The CRJ200 SF and CRJ100 SF would have maximum packing densities of 7.80 and 7.81lbs/cu ft when loaded with PSA pallets. The maximum packing density of an ATR 72-200/-210 LCD freighter in a palletised configuration would range from 8.53-11.19 lbs/cu ft, depending on whether bulk cargo was included.

Containers – 7.0lbs/cu ft

A CRJ100 SF and CRJ200 SF would have the same volumetric payloads in a containerised configuration at a typical express package packing density of 7.0lbs/cu ft.

The CRJ100/200 SF would have a volumetric payload of 8,702-9,492lbs/cu ft when loaded with LSY and ASZ ULDs. In both cases, the CRJ100/200 SF would bulk out, filling the available volume without making use of the entire net structural payload.

At the same express package packing density and in a containerised configuration, an ATR 72-200/-210 LCD freighter would offer a volumetric payload of 10,836-15,652lbs including bulk cargo, and 7,546-12,362lbs when bulk cargo is excluded.

The ATR 72 would therefore have a volumetric payload advantage of 1,344-6,950lbs when bulk cargo is included. This is equal to 14-80% more volumetric payload than the CRJ100/200 SF.

When bulk cargo is excluded, the ATR 72-200/-210 LCD freighter would provide a volumetric payload of 7,546-12,362lbs at this packing density. This is equal to 1,946lbs less, or 3,660lbs more than the CRJ100/200 SF, depending on which containers the aircraft are loaded with.

The CRJ100/200 SF will demonstrate its greatest advantage in volumetric payload when loaded with ASZ containers and compared to an ATR 72 freighter loaded with LD-3 ULDs and no bulk freight. In this scenario the CRJ100/200 SF provides 26% more volumetric payload.

Containers – 9.0lbs/cu ft

At a typical general freight packing density of 9.0lbs/cu ft, the CRJ100 SF and 200SF would again provide identical volumetric capacities when loaded with containers. The CRJ100/200 SF would offer a volumetric payload of 11,189-12,204lbs when loaded with LSY and ASZ ULDs. The aircraft would bulk out in both instances.

At the same packing density an ATR 72-200/-210 LCD freighter would have volumetric capacities of 13,932-16,100lbs including bulk cargo, and 9,702-15,894lbs when bulk cargo is excluded.

The ATR72 freighter would therefore have a volumetric payload advantage of 1,728-4,911lbs if bulk cargo were taken into consideration. This is equal to 14-44% more volumetric payload than the CRJ100/200 SF.

If bulk cargo is excluded, the difference in volumetric payload varies from 2,502lbs in favour of the CRJ100/200 SF to 4,705lbs in favour of the ATR72 LCD freighter, depending on the container type. The CRJ100/200 SF again demonstrates its greatest advantage in volumetric payload when loaded with ASZ containers and compared to an ATR 72 LCD freighter loaded with LD-3 ULDs and no bulk freight. In this scenario the CRJ100/200 SF provides a 26% greater volumetric payload at a packing density of 9.0lbs/cu ft.

Pallets – 7.0lbs/cu ft

In a palletised configuration at a typical express package packing density of 7.0lbs/cu ft, a CRJ100 SF and CRJ200 SF would have the same volumetric payloads. The CRJ100/200 SF would have a volumetric payload of 12,600lbs when configured with PSA pallets and would bulk out at this packing density.

In a typical palletised layout at a packing density of 7.0lbs/cu ft, an ATR 72-200/-210 LCD freighter would have a volumetric payload of 13,825lbs including bulk freight, or 10,535lbs when bulk freight is excluded.

A CRJ100/200 SF would therefore have a 1,225lbs smaller volumetric payload than an ATR 72 LCD freighter when bulk cargo is taken into account. If the ATR 72's bulk cargo capacity is excluded, the CRJ100/200 SF would have a volumetric payload advantage of 2,065lbs at this packing density.

Pallets – 9.0lbs/cu ft

At a general freight packing density of 9.0lbs/cu ft the CRJ100 SF and CRJ200 SF would gross out when configured with PSA pallets. The net structural payload would be reached before all of the available volume is used. This would result in the CRJ100 SF offering a slightly higher volumetric payload of 14,062lbs compared to 14,032lbs for the CRJ200 SF.

In comparison, an ATR 72-200/-210 LCD freighter would have a volumetric payload of 16,845lbs when bulk cargo is included, or 13,545lbs when bulk cargo is excluded.

A CRJ100/200 SF would therefore offer 2,783-2,813lbs less volumetric payload than an ATR72 LCD freighter when the turboprop's additional bulk volume is accounted for. The CRJ100/200 SF would demonstrate a volumetric payload advantage of 487-517lbs in a palletised configuration at a packing density of 9.0lbs/cu ft if the ATR72's bulk cargo volume were excluded.

Range

A CRJ200 SF aircraft's range with a maximum cargo payload will vary from about 850 nautical miles (nm) for an ER variant to 1,200nm for an LR variant. A CRJ100 SF would have similar range capability.

The longest range of an ATR72- LCD freighter with a full payload is 600-900nm depending on the variant with a -500 series aircraft offering more range. A CRJ200 SF could offer double the range of an ATR 72 LCD freighter when both types are operated at their maximum payloads.

Acquisition cost

"The 2016 conversion price for a CRJ100/200 SF is $1.80 million," explains Convey.

Market values of CRJ100s and CRJ200s have fallen over the past few years as an increasing number of passenger aircraft have been retired by regional operators in the US.

The estimated current market value (CMV) for a CRJ100 in half-life maintenance condition with half-life engines is $1.36-2.38 million for a 15-20-year-old ER variant, to $1.41-2.46 million for a 15-20-year-old LR aircraft *(see table, this page)*.

This compares to an estimated CMV of $1.54-2.54 million for a 15-20-year-old CRJ200 ER, and $1.60-2.65 million for a 15-20-year-old CRJ200 LR.

The combined acquisition and conversion costs are therefore $3.16-4.26 million for a CRJ100 SF, and $3.34-4.45 million for a CRJ200 SF.

IPR Conversions says that the cost of its LCD and structural tube conversion for the ATR 72 is $1.58 million. The cost of the structural tube conversion alone is $490,000.

The youngest available ATR 72-200/-210 series aircraft are 18 years of age. These have an estimated CMV of $.3.49 million *(see table, this page)*. A 20-year-old ATR 72-200/-210 has an estimated CMV of $4.01 million. Since ATR72-500s are also likely to be converted, the acquisition costs for this model are also considered. The CMV range for 15-20-year-old ATR72-500 aircraft is $6.10-8.05 million.

The combined acquisition and conversion costs for an ATR 72 LCD freighter could therefore be $5.07-5.59 million for an ATR 72-200/-210, and $7.68-9.63 million for an ATR72-500.

The cost of acquiring and converting a CRJ100/200 SF could therefore be $620,000 to $6.47 million less than that required for an ATR72 LCD freighter, depending on the specific variant and its vintage. The smallest cost difference would be between a 15-year-old LR variant of the CRJ200 SF and a 20-year-old ATR 72-200/-210 LCD freighter. The largest difference in cost would be between a 20-year-old ER variant of the CR100 SF and a 15-year-old ATR72-500 LCD freighter.

"We estimate that the total on-ramp cost for a CRJ100/200 SF will be $4.0-5.0 million," explains Convey.

The total on-ramp cost for a converted freighter is the sum of the aircraft's acquisition and conversion costs, plus any maintenance-related outlays. Most freighter operators will combine the conversion process with a major base maintenance check. This optimises aircraft downtime and man-hours (MH), since both processes require deep airframe structural access.

The CRJ100 and CRJ200 have the same maintenance requirements, costs and intervals.

CRJ100/200 SF & ATR 72 LCD FREIGHTER CAPITAL COSTS

Aircraft Type	Year of manufacture	CMV ($-millions)	Conversion cost ($-millions)	Acquisition & conversion cost ($-millions)
CRJ100 ER	1996	1.36	1.80	3.16
CRJ100 ER	2001	2.38	1.80	4.18
CRJ100 LR	1996	1.41	1.80	3.21
CRJ100 LR	2001	2.46	1.80	4.26
CRJ200 ER	1996	1.54	1.80	3.34
CRJ200 ER	2001	2.54	1.80	4.34
CRJ200 LR	1996	1.60	1.80	3.40
CRJ200 LR	2001	2.65	1.80	4.45
ATR 72-200/-210	1996	3.49	1.58	5.07
ATR 72-200/-210	1998	4.01	1.58	5.59
ATR72-500	1996	6.10	1.58	7.68
ATR72-500	2001	8.05	1.58	9.63

CMV Source: Avitas - Values are for aircraft in half-life maintenance condition as of 1st quarter 2016.

Potential market

"We have already received 40 orders for CRJ100/200 SF conversions and expect to convert 200-250 over the life of the programme," explains Convey.

"I believe that most CRJ100/200 SFs will be operated on longer-range regional services with thin demand where the CRJ100/200's additional speed will give them an advantage over similar-sized turboprops," adds Convey. These might be sectors that are too long to be economically served by turboprops, but which do not support the level of demand required for narrowbody freighters, such as the 737.

Turboprops generally burn less fuel and can offer lower cash operating costs on short sectors than RJs, *(see The fuel burn performance & costs of turboprops versus RJs, Aircraft Commerce, June/July 2013, page 13)*.

Convey believes that the CRJ100/200 SF's additional speed would give it an advantage over competing turboprops on sectors in excess of 500nm.

The CRJ100/200 SF's speed advantage over competing turboprop freighters, such as the ATR 72, could translate into significant time savings on longer sectors. A previous analysis by *Aircraft Commerce* revealed that on typical intra-European airport pairs, a CRJ200 LR would demonstrate sector time savings of 17, 28 and 61 minutes when compared to an ATR 72 on increasing route lengths of 200, 300 and 600nm *(see The fuel burn performance & costs of turboprops versus RJs, Aircraft Commerce, June/July 2013, page 13)*.

"A time saving of 30-45 minutes per sector starts to become material for express package operators," claims Petohleb. The hub-and-spoke networks of express package operators can be time-sensitive, since they often provide next-day delivery services and rely on efficient interlining between different aircraft. The additional speed of a CRJ100/200 SF could allow services from more distant communities to be fed into hubs in time for that cargo to connect to onward interlining services. These routes may not have the level of demand required for a narrowbody freighter and might not make the interline connection in time if operated by a turboprop.

"The CRJ100/200 SF will also appeal to ad hoc charter operators which provide time-critical shipments of items, such as critical factory components," continues Petohleb.

"IFL Group is the first customer for AEI's CRJ freighter conversion," says

A large percentage of the CRJ100 and CRJ200 passenger fleet is concentrated among a small number of US regional airlines, and operated on feeder services for major carriers. More than 750 CRJ100/200 aircraft will fall within the typical conversion age range at some point between 2016 and 2021.

Jacob Netz, senior analyst at Air Cargo Management Group, expressing his own opinion. "It owns Contract Air Cargo which operates ad hoc cargo services and contract charters for 'just in time' industries such as General Motors and Ford. The CRJ is suitable for some of their missions."

AEI also believes that in some circumstances a CRJ100/200 SF could demonstrate lower operating costs per available tonne mile (ATM) than an ATR 72 freighter on long sectors. This is based on the assumption that the ATR 72's lower fuel burn and fuel costs would be cancelled out by the CRJ's lower capital costs and its potential ability to generate more ATMs on longer routes due to the superior payload-range capability of certain variants.

"The CRJ100/200 SF offers a very attractive value proposition for regional feed operators when you combine the low aircraft acquisition cost, low conversion cost, jet speed and range capabilities and the large cargo door for both containerised and unconventional cargo," says Petohleb. "The CRJ100/200 SF is an ideal replacement candidate for very old aircraft such as the CV580, for aircraft operating existing long and thin turboprop routes, and for under-utilised larger-gauged aircraft."

AEI believes that there will be a global market for the CRJ100/200 SF. "In the West the CRJ100/200 SF will be used on existing routes where speed is needed," claims Convey. "They will also be used in developing countries to open new routes."

There is some scepticism over the size of the potential market for CRJ100/200 SFs. "I can see only a limited demand for the current CRJ conversion by AEI," says Jacob Netz, expressing his own opinion. "Only a few airlines really need the jet speed advantage to operate long, thin and niche routes."

Potential feedstock

There are 550 passenger-configured CRJ100s and CRJ200s in service, and a further 267 aircraft in storage.

Most of the in-service and stored CRJ100 and CRJ200 fleet will fall within the typical feedstock age range when conversions begin in December 2016, or will reach the 15-year-old threshold by 2021.

There will be 339 in-service and stored CRJ100 or CRJ200s within the typical feedstock age range by December 2016. A further 439 aircraft will enter the conversion age range by 2021. This means that a total of 778 aircraft will fall within the typical age range for conversion at some point during 2016-2021.

Of these 778 aircraft, 488 are CRJ200 LRs, 218 are CRJ200 ERs, 57 are CRJ100 ERs and six are CRJ100 LRs. There are also six CRJ200B ERs and two CRJ200B LRs.

A large portion of the CRJ100 and CRJ200 fleet has historically been operated by regional airlines in the US. Many of them were and are operated on regional feeder services under capacity purchase agreements (CPAs) with the major US carriers.

An analysis of the 778 aircraft that will fall within the typical conversion age range during 2016-2021, reveals that six of the eight largest operators are US-based airlines. These six airlines operate 63% of the in-service and stored aircraft that represent current or future conversion feedstock. The largest fleets of in-service and stored CRJ 100s and CRJ200s belong to SkyWest Airlines (167), Endeavor Air (127), Express Jet (73) and Air Wisconsin (71).

The concentration of a large number of feedstock aircraft with a small number of US airlines offers the benefits of commonality to any operators considering multiple conversions. Aircraft that have been in service with the same operator will generally have had the same modifications applied. They will also have been maintained and operated to the same standard under the same procedures. A common fleet can reduce the requirement for operators to hold multiple spares inventories and also reduce their flight crew and maintenance personnel training costs.

Summary

The CRJ100/200 SF is the only large door cargo conversion programme in development in the regional jet market.

The potential feedstock situation has been boosted by the increasing retirement of CRJ100 and CRJ200 passenger aircraft by US regional airlines. This has resulted in a decline in market values and a large number of stored aircraft.

The CRJ100/200 SF's main market could be on long thin routes that require the speed of a jet, but do not have the level of demand necessary for narrowbody freighter operations.

The CRJ100/200 SF's most likely competition will come from ATR72 LCD freighters.

The turboprop would likely be the more efficient choice for routes up to 500nm. On sectors longer than 500nm, the CRJ100/200 SF's speed advantage could result in time savings over turboprops that are large enough to make it the more appealing option to express-package or time-critical ad hoc charter operators.

There is some evidence that in certain configurations, a CRJ100/200 SF could demonstrate lower operating costs per ATM than a turboprop freighter. This would occur if the turboprop's lower fuel burn is outweighed by the CRJ100/200 SF's lower capital costs and its generation of more ATMs in certain scenarios. AC