757 modification & upgrade programmes

The 757 requires few of the avionic or noise reduction programmes that older aircraft do. There is a blended winglet programme to reduce fuel burn & performance enhancement, but the most prominent modification programmes for the 757-200 are the passenger-to-freighter conversions.

There are several categories of modifications and upgrades for the 757, including weight upgrades, performance enhancement modifications, passenger-to-freighter modifications, and avionic upgrades.

Weight upgrades

The weight specifications of the 757-200 are simpler than for other aircraft types. There are five different maximum take-off weight (MTOW) variants *(see 757 specifications, page 12)*, and all of which have the same fuel capacity. There are also only two maximum zero fuel weight (MZFW) options; all MTOW options have an MZFW of 184,000lbs, except the 255,000lbs MTOW variant which has an MZFW of 188,000lbs, therefore offering only a few possibilities for specification weight increases.

Most aircraft have MTOWs of 240,000lbs or higher *(see 757 specifications, page 12)*, so the majority are only likely to require small increases in MTOW capability. Most airlines are unlikely to require any weight increases, and changes are only likely to be made during conversion to freighter. Aircraft with MTOWs up to 250,000lbs are permitted an MZFW of 188,000lbs, while aircraft with an MTOW of 255,000lbs will have their MZFW capped at 186,000lbs, thereby reducing structural payload by 2,000lbs. Many aircraft may therefore need to have their MTOWs downgraded during conversion to make full use of payload potential. Many aircraft, however, are also likely to require an increase in MZFW from 184,000lbs to 188,000lbs, which must be done via Boeing at a cost of $150,000-170,000, providing aircraft are eligible.

Noise compliance

The 757-200 with the highest MTOW of 255,000lbs and powered by all four main engine types (the PW2037, PW2040, RB211-535E4 and RB211-535E4-B) is compliant with Stage 3 noise requirements.

The highest gross weight variant of the 757-200 is permitted a cumulative noise emission of 293.4 EPNdB, compared to actual cumulative noise readings of between 283.2 EPNdB for the PW2037-powered aircraft and 275.0 EPNdB for the RB211-535E4-B-powered aircraft. This provides the four variants with a Stage 3 compliance margin of 10.2 to 18.4 EPNdB.

Stage 4 noise rules are that aircraft manufactured/certified after 1st January 2006 should have a cumulative noise reading 10 EPNdB lower their permitted Stage 3 cumulative noise emissions. Aircraft certified prior to this date, such as the 757, are not required to be Stage 4 compliant, although there may be legislation in the future that requires older aircraft to be. The Stage 3 compliant margins of the four different variants of the high gross weight 757-200 are sufficient for the aircraft to meet Stage 4 compliance without any requirement for noise reduction modifications, since their Stage 3 compliant margins are all at least 10 EPNdB. There is therefore no need for noise reduction kits, or modifications.

Performance enhancement

Although the 757 meets Stage 3 and Stage 4 noise emissions requirements, there is a performance improvement programme from Aviation Partners Boeing which primarily reduces fuel burn. The modification features installation of blended winglets to reduce induced drag, and so lower fuel burn. Block fuel burn reduction varies from about 2% for a 500nm sector up to about 4.7% for a 3,500nm sector. The benefits of the blended winglets are: increased payload-range performance; improved take-off field performance; lower noise emissions; and reduced throttle settings and consequent reduced engine deterioration.

The annual savings in fuel costs are substantial at current fuel prices of about $1.50-1.65 per US Gallon (USG).

The majority of 757-200s are used on average sectors of about 1,000nm, with an average time of 2.7 flight hours (FH), and generate about 1,050 flight cycles (FC) per year. On this sector length aircraft burn in the region of 2,700-3,000USG, depending on engine type and operating conditions *(see 757 in service & operations, page 15)*. The blended winglets reduce fuel burn by about 3.1% on this sector length: equal to 84-93USG per flight or 88,000-97,000USG per year. At current fuel prices this provides a saving of up to $161,000 per year, against a list price of $1.05 million for the winglets, which will therefore pay for themselves in about six years.

Larger fuel burn reductions are realised with longer sector lengths. Continental Airlines, for example, uses some of its 757-200s on its thinner transatlantic routes. Fuel burn on a 3,000nm route is about 8,500-9,000USG, depending on engine type and operating conditions *(see 757 in service & operations, page 15)*. Blended winglets will reduce fuel burn by about 4.5% and 405USG on this route length.

These sectors have flight times of about 7.2FH, and the aircraft will generate about 4,500FH and 625FC per year. Annual fuel burn reduction is thus about 253,000USG, equal to an annual saving of up to $415,000. Payback is realised in less than three years in this scenario.

Freighter conversion

There are four different passenger-to-freighter modification programmes for the 757-200, offered by Boeing, Precision Conversions, Alcoa-SIE (ASCC) and Bedek Aviation/ST Aero.

The modification offered by Boeing is the oldest, but its only customer to to date has been DHL. The modification, designated the 757-200SF, provides an aircraft that accommodates 14 125-inch wide by 88-inch long containers that are standard for narrowbody freighters. The containers each have an internal volume of 440 cubic feet, giving the main deck a total freight volume of 6,160 cubic feet. Added to the belly capacity of 1,790 cubic feet, total aircraft freight volume is 7,950 cubic feet.

757-200PCF PAYLOAD CHARACTERISTICS-PRECISION CONVERSIONS

Aircraft variant	757-200	757-200	757-200	757-200
Engine type	RB211-535E4	RB211-535E4	PW2000	PW2000
Etops equipped	Yes	No	Yes	No
MTOW lbs	250,000	250,000	250,000	250,000
MZFW lbs	188,000	188,000	188,000	188,000
OEW lbs	116,041	115,541	115,441	115,041
Gross structural payload lbs	71,959	72,459	72,559	72,959
main deck containers				
Number of containers	15	15	15	15
Container tare weight lbs	7,140	7,140	7,140	7,140
Container volume cu ft	8,390	8,390	8,390	8,390
Net structural payload lbs	64,819	65,319	65,419	65,819
Maximum packing density (lbs/cu ft)	7.73	7.79	7.80	7.84
Volumetric payload lbs	58,730	58,730	58,730	58,730

757-200ASF PAYLOAD CHARACTERISTICS-ALCOA-SIE

Aircraft variant	757-200	757-200	757-200	757-200
Engine type	RB211-535E4	RB211-535E4	PW2000	PW2000
Etops equipped	Yes	No	Yes	No
MTOW lbs	250,000	250,000	250,000	250,000
MZFW lbs	188,000	188,000	188,000	188,000
OEW lbs	117,864	117,364	117,264	116,764
Gross structural payload lbs	70,136	70,636	70,736	71,236
main deck containers				
Number of containers	14 + 1/2	14 + 1/2	14 + 1/2	14 + 1/2
Container tare weight lbs	6,964	6,964	6,964	6,964
Container volume cu ft	8,170	8,170	8,170	8,170
Net structural payload lbs	63,172	63,672	63,772	64,272
Maximum packing density (lbs/cu ft)	7.73	7.79	7.81	7.87
Volumetric payload lbs	57,190	57,190	57,190	57,190

The list price of $8.5 million is viewed as high, especially compared to other conversions that accommodate more containers at lower prices.

Precision Conversions is the first independent passenger-to-freighter modification to receive its supplemental type certificate (STC), for RB211-powered aircraft. It will receive an amended STC for PW2000-powered aircraft when the first is converted at the end of 2005. The designation for aircraft converted by Precision Conversions is 757-200PCF. The modification has a list price of $4.65 million, including the cargo handling system which is supplied by Ancra.

This modification seals the first door on the passenger aircraft and installs a new crew door further forward, allowing 15 standard 88-inch long containers to be accommodated, providing 6,600 cubic feet of freight capacity. When added to the underfloor space of 1,790 cubic feet, the aircraft has a total freight volume of 8,390 cubic feet.

One important criterion following conversion is the aircraft's MZFW. This will be 184,000lbs or 188,000lbs for aircraft that have an MTOW of up to 250,000lbs. For MZFW to be upgraded to 188,000lbs, owners and operators have to get the aircraft upgraded by Boeing, provided the aircraft is eligible.

Aircraft with an MTOW of 255,000lbs will have their MZFW capped by Boeing at 186,000lbs, thus taking out nearly one ton of payload capability from the aircraft. It is therefore preferable for operators to have MTOWs downgraded to 250,000lbs. The MTOW reduction of 500lbs reduces range performance by only about 200nm when the aircraft is carrying high payloads.

Precision Conversions' converted aircraft, with RB211-535E4 engines, has a basic empty weight of about 115,541lbs. This is the weight of an Etops-equipped aircraft without crew or tare weight of containers. The actual weight will vary between individual aircraft. Precision Conversions estimates a non Etops-equipped aircraft will be about 500lbs lighter. About 500lbs should be added for crew, taking operating empty weight (OEW) to 116,041lbs for an Etops-equipped aircraft and 115,541 for a non-Etops equipped aircraft.

These weights allow a gross structural payload of 71,959-72,459lbs *(see first table, this page)* for aircraft that have an MZFW of 188,000lbs.

The basic empty weight (BEW) of PW2000-powered aircraft, however, is expected to be about 600lbs less than their RB211-powered counterparts. With crew weight considered, these aircraft will have gross structural payloads of 72,559-72,959lbs *(see first table, this page)*.

The tare weight of a standard 125-inch wide X 88-inch long container is 476lbs, making total tare weight 7,140lbs for the 15 containers.

This takes net structural payload down to 64,819-65,319lbs for RB211-powered aircraft, and down to 65,419-65,819lbs for PW2000-powered aircraft *(see first table, this page)*.

These allow maximum packing densities of 7.75-7.85lbs per cubic foot. When freight is packed at 7.0lbs per cubic foot, the aircraft's volumetric payload is 58,730lbs *(see first table, this page)*.

Alcoa-SIE (ASCC) is developing a passenger-to-freighter modification for the 757-200 that accommodates 14 full containers plus a half-sized container in the fifteenth position at the rear of the fuselage. ASCC has developed this modification by retaining the first door of the passenger-configured aircraft so that the first cargo position is aft of the position for the first container on the Precision Conversions modification. For this reason, the ASCC conversion accommodates 14 full containers plus a demi container in the 15th position. This gives the aircraft similar freight volume to the Boeing conversion.

ASCC's conversion is designated the 757-200ASF and has a list price of $3.75 million, $0.9 million less than Precision Conversions' 15-container modification.

ASCC is still in the process of developing the modification for the RB211-powered aircraft, and says it expects to receive its STC by the end of 2005. As with all other modifications, MZFW will be either 184,000lbs or 188,000lbs, depending on the aircraft converted. MZFW can be raised from 184,000lbs to 188,000lbs for eligible

All 757s will be compliant with some mandatory avionic requirements, such as B-RNAV. Other avionic modifications, like 8.33KHz radio spacing, are only mandatory in Europe. The consequence of this is that aircraft may require several expensive modifications when they change operators and move from one part of the world to another.

aircraft by the owner or operator by paying Boeing for a weight increase.

The BEW of an Etops-equipped aircraft is 117,364lbs, and OEW including crew is 117,864lbs. This gives the aircraft a gross structural payload of 70,136lbs. This will be about 500lbs more for a non-Etops equipped aircraft *(see second table, page 12)*. The equivalent PW2000-powered aircraft will be about 600lbs lighter, and so have structural payloads of 70,736lbs and 71,236lbs.

The tare weight of each of the 14 main containers is 476lbs, while the 15th demi container has a tare of 300lbs. Total tare is thus 6,964lbs. This gives the RB211-535E4-powered, Etops aircraft a net structural payload of 63,172lbs *(see second table, page 12)*. Net structural payloads for the PW2000-powered aircraft are adjusted relative to their difference in BEW.

The volume of the 14 main containers, demi container and underfloor space totals 8,170 cubic feet, which is 220 cubic feet less than an aircraft converted by Precision Conversions. This volume allows a maximum packing density of 7.73lbs per cubic foot. Volumetric payload for freight packed at 7.0lbs per cubic foot is 57,190lbs *(see second table, page 12)*.

The third conversion is being developed by Israel Aircraft Industries (IAI) and ST Aero, which have obtained a licence from Boeing for a programme to follow Boeing's first conversion, which accommodated 14 and a half containers. IAI and ST Aero will be the two conversion facilities. This conversion will provide an aircraft that can accommodate 15 full-sized containers. STC is not expected until mid 2007. The conversion will have a list price of $5.5million, but will not include the cargo handling system. After sales support and weight upgrades will be provided by Boeing, and the STC is not expected until mid 2007.

The conversion will have the same MZFW as modifications offered by Precision Conversions and ASCC, and the the aircraft will have a gross structural payload of 68,500-72,500lbs depending on engine type and MZFW. Boeing is currently conducting a feasibility study for an upgrade of MZFW beyond 188,000lbs that would allow higher structural payloads.

Avionic upgrades

As with all other aircraft types, there are a series of avionic upgrades that only apply to operations in certain parts of the world. This means some aircraft will have been modified, while others will have to be if they change operators and fly in an area of the world where these modifications and mandatory.

The first of these is 8.33KHz radio spacing which is mandatory in Europe. The cost of components for this is about $30,000.

Installation of a traffic collision avoidance system (TCAS) and Mode S air traffic control (ATC) transponder was required worldwide by the end of 1991. The upgraded ATC transponder was installed on the 757 production line from line number 300 onwards. The transponders have gone through several upgrades, one of which was to comply with European requirements for enhanced surveillance. TCAS was mandatory for all aircraft from 1993.

Aircraft built before ATC Mode S and TCAS requirements may need avionic upgrades. Jacob Barak, manager of avionics at El Al Engineering estimates that the cost of new TCAS components is about $80,000.

Enhanced ground proximity warning systems (EGPWS) or terrain awareness systems (TAWS) are required by the Federal Aviation Administration (FAA), the Joint Airworthiness Authority (JAA) and the International Civil Aviation Organisation (ICAO) for worldwide application. The FAA required that EGPWS/TAWS be installed on new production aircraft from March 2002, and that previously built aircraft be retrofitted by March 2005. The JAA required the equipment to be installed on new production aircraft from October 2001 and retrofitted to previously built aircraft by January 2005. ICAO's dates were January 2001 for new production aircraft and January 2003 for previously built aircraft. Boeing actually started installing TAWS/EGPWS equipment on the 757 production line in May 1998.

Barak estimates the cost of TCAS/EGPWS components at $80,000 for any aircraft that still need to be retrofitted.

Reduced vertical separation minima (RVSM) are only mandatory in Europe and the Atlantic Ocean area, and are related to the calibration of pitot tubes to ensure that accurate altimeter readings are given. They do not require installation of new avionics.

Basic area navigation (B-RNAV) requirements have to be met in Europe. These require the aircraft not to deviate more than five miles of the planned track only 5% of the time. "All 757s are B-RNAV compliant since they have an FMS,"explains Barak. "Precision area navigation requirement (P-RNAV) is optional in most areas, but required in a few. This requires a deviation of no more than 300 feet from the planned track, and that waypoints for standard instrument departures (SIDs) and standard terminal arrival routes (STARs) be shown on a navigation screen. P-RNAV therefore requires the installation of a flat screen on the flightdeck. This does not have to be installed on the 757, but P-RNAV also requires that the navigation database fed into the flight management computer is P-RNAV compliant." AC