747-400 modification programmes

The modification programmes for the 747-400 series fall into the categories of freighter modifications, engine upgrades, weight upgrades and avionic installations and improvements.

Modifications and upgrades for the 747-400 family fall into different groups. The first comprises service bulletins (SBs) and airworthiness directives (ADs), all of which are listed on the Federal Aviation Administration's (FAA's) website, together with their compliance date. Other groups include passenger-to-freighter conversions, and avionics upgrades, such as electronic flight bags (EFBs) and FMS memory enhancements.

All aircraft types have been affected by, and have had to comply with, a variety of avionics upgrades, including: traffic avoidance collision system (TCAS); enhanced ground proximity warning system (EGPWS) and terrain awareness warning system (TAWS); reduced vertical separation minima (RVSM); 8.33kHz VHF communication frequency spacing for Europe; Mode-S transponders; FANS-1; basic area navigation (B-RNAV) in Europe; and precision area navigation (P-RNAV).

Many 747-400 operators plan to carry out major upgrades to the interiors and in-flight entertainment (IFE) systems on board their aircraft. These will generally be highly customised projects configured on a case-by-case basis.

Freighter conversions

The 747-400F and -400ERF are popular among blue-chip operators. The 747-400 production line will close in 2009, so older passenger and Combi aircraft are increasingly attractive for conversion into freighter configuration.

There are two major programmes under way: the original equipment manufacturer's (OEM's) Boeing Converted Freighter (-BCF); and IAI-Bedek's Bedek Special Freighter (BDSF) conversion. The specification for both Boeing- and IAI-converted aircraft is similar. Both have a fuel capacity of 53,765 US gallons (USG), and total cargo volumes of 24,962 cubic feet with 30 pallets on the maindeck. They also have gross structural payload limits that are within 1,000lbs of each other.

Launched in January 2005, Boeing's own 747-400BCF programme is aimed as a replacement for the 747-200F, with the advantage of more fuel-efficient engines and a two-man flightdeck. The conversion adds a side cargo door, and modifies the layout so that it is almost identical in freight volume to the 747-400F. The converted aircraft also have 1,000nm longer range than the 747-200F. Unlike the -400F, converted aircraft retain the stretched upper passenger deck, albeit with internal modifications, and do not have the -400F's upward-hinging nose door.

Other changes include removing part of the upper-deck floor to accommodate full-height containers, and installing a fully powered cargo handling system.

The first 747-400BCF (ex-South African Airways) was completed in December 2005 and delivered to Cathay Pacific. TAECO in China performs the conversions of the Boeing modification, and Boeing also sells kits to airlines (and third parties) that wish to perform the conversion themselves.

The Boeing conversion allows a maximum take-off weight (MTOW) of 870,000lbs, and a payload including container tare weight of approximately 251,000lbs. This is derived from a maximum zero fuel weight (MZFW) of 610,000lbs minus a basic operating empty weight (OEW) of 359,000lbs. The aircraft has a maximum design range of about 4,076nm.

At the time of writing there are 14 -BCFs in service with Cathay Pacific (4), Japan Airlines (3), Korean Air Cargo (2), SIA (with two that are operated by Dragonair), and Guggenheim (with two leased to Martinair and a third leased to Great Wall). Outstanding orders for the Boeing conversion comprise 35 firm orders and 19 options.

The IAI-Bedek -400BDSF modification programme is the second option. IAI-Bedek received supplemental type certificates (STCs) for both the 747-400 and 747-400 Combi modifications in

The first Boeing-converted 747-400s have been delivered to end-users. While factory-built freighters can no longer be ordered, market values of passenger aircraft are too high to make conversion economic.

The -T upgrade for the RB211-524 incorporates the high pressure module from the Trent 700 primarily to improve reliability. There is an added bonus of a small reduction in fuel burn.

2006. In 2003, the company teamed with Eolia Ltd to create a joint venture company based in Cyprus, called PSF Conversions LLP, which owns the STCs. PSF Conversions allocates conversion slots to customers, and says it will carry out seven simultaneous conversions in Israel and abroad. Customers include Guggenheim, Rabobank, GECAS, Atlas Air, Eva Air and Asiana.

The converted aircraft carries 30 positions in the main deck, and part of the upper-deck floor is modified to enable more 10-feet-high unit load device (ULD) positions.

According to IAI, the modified aircraft's specification weights are an MTOW of 870,000 lbs, an MZFW of 610,000lbs to 635,000 lbs, and a maximum landing weight (MLW) of 652,000lbs. Total containerised volume is 20,820 cubic feet.

The maximum load of all cargo including container tare weight is 251,400lbs. This is calculated from an MZFW of 610,000lbs less the basic OEW of 358,600lbs.

A basic price for the -BDSF conversion of a passenger aircraft is $20 million, and the basic price for a Combi aircraft is $15.5 million. These prices exclude the Ancra-supplied cargo loading system, or any of the weight upgrades or maintenance.

RB211-524-G/H core upgrade

Investors should consider the engine model when evaluating candidate aircraft for conversion to freighter. The factors to consider are: engine weight; fuel consumption; engine maintenance costs; aircraft market and purchase value; and the popularity of the engine type. In terms of weight, a 747-400 equipped with RB211-524s will have an OEW of 3,000lbs more than a similar aircraft powered by CF6-80C2s. While this may seem a weak point, it only penalises RB211-powered aircraft if they are loaded with their maximum structural payload. This only occurs if all the available cargo volume is filled at the maximum possible cargo loading density. This is an unlikely scenario, however.

If these aircraft are loaded at their maximum volumetric payload, packed at a typical density of 7lbs or 8lbs per cubic foot, the 3,000lbs higher OEW will not affect the payload carried. In terms of weight, the PW4056 sits between the RB211 and CF6-80C2.

It should be noted that RB211s are slightly more fuel efficient than CF6-80C2s and PW4056s. This superior fuel efficiency can, for some mission profiles, offset the engines' higher weight. The PW4056 powers most of the cargo-converted 747-400s to date, which are the ex-Korean and ex-SIA aircraft. As for Cathay Pacific, its entire 747 fleet has historically been powered by RB211s, so it is likely to prefer RB211-powered aircraft to maintain commonality across its 747 fleet.

In the 1990s Rolls-Royce introduced significant turbomachinery variation by offering a mid-life retrofit for the RB211-524G (58,000lb thrust) and RB211-524H (60,600lb thrust) with the core '04 module', the complete high-pressure section, from the Trent 700. This reduced fuel consumption and increased exhaust gas temperature (EGT) margin. The resulting model with the retrofit was designated with a '-T' suffix. Subsequent new-build RB211s, such as those ordered by Cargolux for its new 747-400Fs, had the modification already incorporated.

Interiors

According to Craig Larson, Boeing's director of marketing services, interiors are where most of the activity is on the 747-400. "The predominant focus of our interior work is certifying the installation of new seats and integrating new IFE equipment. The latter usually requires an upgrade to the IFE cooling system to provide higher capacity airflows. The other issue is that lie-flat seats are heavier, with more actuators, than earlier premium seats, so we often have to make enhancements to the floor structure to accommodate the heavier weights."

"Installing new seats can require installation of additional decompression vents, so as not to overload the floor structure," adds Larson.

MTOW upgrades

While there is a maximum structural weight which the aircraft was built to take, airlines will often order the aircraft at a lower MTOW to reduce landing fees. As the airline's mission requirements change, or the aircraft is sold to a new operator, Boeing will often certify changes to the MTOW and/or MLW, to accommodate the new customer's route structure. This does not result in a physical change to the aircraft. The only exception is on the 747-400D, which is built for short-range operations in Japan. This requires different tyres and brakes to be fitted.

"These may have to be updated, depending on what weights the aircraft goes to," says Larson. "Besides this, structural weight aspects are generally paper changes to meet airline requirements, and go up to 870,000lbs if they have the tail fuel tank activated. The aircraft is either delivered with provision for tail fuel, or it has tail fuel activated."

Class-3 electronic flight bag

A major change to the flightdeck is the Boeing Class-3 EFB, which is integrated into the avionics on the flightdeck. "The side console is modified and the display unit is installed in the sidewall, while electronics units are

Boeing is planning to offer a retrofit of the 747-8's flight management computer into the -400 series.

installed in the electronics bay to integrate with various systems such as the flight management computer (FMC), flightdeck printer, aircraft communication and reporting system (ACARS), and the flightdeck entry video surveillance equipment," says Larson.

The purchase price of the EFB itself is about $200,000. This covers a kit of parts including the two display units, two electronics units, the sidewall console, wiring, fibre optics, and the installation instructions. The price does not include labour to retrofit the unit.

Flight management computer

Boeing is defining an FMC memory increase. "We are a couple of years out on that, but as the air traffic control (ATC) system has evolved, operators need to be able to load more routes and waypoints into the FMC," says Larson. "Our current plan is to use the upgraded FMC, which we have designed for the 747-8, and retrofit it onto the 747-400. This should be a 'plug and play', such that we only need to remove one box and replace it with a new one. The wiring will therefore not have to be changed. We would issue an SB for the installation, and the customer would buy the FMC directly from the supplier."

747-400 EGPWS/RAAS

Honeywell offers an improved EGPWS, which can include a runway awareness and advisory system (RAAS). This system facilitates aural warnings on the ground and in the air during the final approach phase. The system has been installed by Lufthansa Technik (LHT) on Lufthansa's 747-400s since 2005. Following a successful trial phase, it is now permanently activated. LHT say that installation only requires three man hours (MH), and is carried out primarily via a simple software upload for the 747-400.

Mode-S transponder

SB 747-34-2815 requires that to fulfil the European ATC requirements, Mode-S 'enhanced surveillance' functionality should be implemented with effect from 31 March 2007 for Instrument Flight Rules (IFR) flights as general air traffic (GAT).

The modification enables the transmission to the ground of elementary surveillance (ELS) parameters. These comprise the Mode-S address, flight number, altitude report, flight/ground status, transponder capacity, RA report, Surveillance Identifier (SI) code. The modification also enables the transmission of enhanced surveillance (EHS) parameters: magnetic heading, indicated airspeed, vertical speed, roll angle, track angle rate, ground speed, and selected altitude. About 140 MH are required for the modification.

Trim air diffuser

In trim air diffuser ducts (TADDs) hot bleed air is mixed with the conditioned air from the packs. On the 747-400, the TADDs are located between the wing centre section and the main deck floor. Several operators have reported heat damage to the TADDs. This can lead to a disconnection of the TADDs from the titanium trim air ducts, which results in the release of hot air onto the surrounding structure, an inability to control the cabin temperature, and hot floor and sidewalls.

According to LHT, an AD (AD2007-07-03, dated 28 March 2007) has been issued to prevent fuel or vapours leaking into areas where ignition sources may be present. The AD mandates repetitive inspections every 1,200FH for hot air leaking from the TADDs, and a general visual inspection for damage to, or discrepancies with, the TADDs every 12,000FH. Assuming a daily utilisation of 15FH, the first inspection must be completed by 20 July 2007. If any leaks are found during the inspection, a general visual inspection must be performed before further operations.

The hot air leak inspection uses 13MH, and aircraft downtime is about seven hours. The general visual inspection uses about 90 MH, and overall downtime is 32 hours, according to LHT.

Hydraulic heat exchanger

SB 747-29A2104 R/I 02 and AD 2004-10-06 specify the elimination of arcing or sparking between the hydraulic heat exchanger penetration fittings and the rear spars, due to inadequate electrical bonding at the interface between the fitting and the spar during a lightning strike event. Therefore, to eliminate the potential for arcing or sparking, the application of an alodine protective coating (according to the SB) is required. According to LHT 36MH are required to carry out this modification, and work should be completed during a heavy maintenance visit, prior to 21 June 2009.

Nose landing gear

To ensure the safety of maintenance staff from the uncontrolled closing of the 747-400's nose landing gear doors, several bearings of the ground door release mechanism must be replaced. This will eliminate the problem of seized bearings, which cause the mechanism to move back into the normal (closed) position while the handle is in the open position. Boeing is also expected to offer an additional locking feature as a solution to this problem. The modification will require 38MH per aircraft. AC