A330-200/-300 modification programmes

The major modification programmes for the A330-200/-300 are avionics upgrades for surveillance and more accurate navigation, structural modifications, and engine upgrades.

Upgrades and modifications for A330 aircraft fall into three categories: flightdeck avionics; structural modifications; and engine performance enhancements.

Avionics upgrades

There is a lot of focus on upgrading flightdeck avionics to meet the latest navigation and surveillance requirements. Airbus is responding to increased worldwide use of automatic dependent surveillance (ADS-B) and required navigation performance (RNP). ADS broadcasts position, heading and altitude information from the aircraft. ADS-OUT receives this information at ground stations for display on air traffic control centres. ADS-IN gives aircraft the ability to receive the information and display it for aircraft in their immediate area on a flightdeck screen.

Although most A330s are already equipped with all the sensors for the necessary 'ADS-B-OUT' broadcast functions, including Mode-S transponders and 'extended squitters', most operators have not yet 'activated' their inherent ADS-B potential. This is due in part to a lack of worldwide ADS-B coverage.

Based on successful trials, notably in Australia, an optional service bulletin (SB) became available in March 2008 to allow A330 operators to implement ADS-B-OUT broadcasts so that ADS-B ground surveillance stations can track aircraft with precision, even in airspace not covered by radar. The required equipment includes: the existing elementary surveillance (ELS) and enhanced surveillance (EHS) air traffic control (ATC) transponder; plus a global position system (GPS)-equipped multi mode receiver (MMR), which recently-built aircraft already have installed as standard specification.

Dimitri Carstensen, avionics senior engineer at Airbus Customer Support, explains that the next stage of ADS-B, referred to as 'ADS-B-IN', will allow A330s to track other aircraft which are broadcasting using ADS-B-OUT. This will be addressed by another set of SBs to be released in the second quarter of 2009.

Airbus has developed this functionality over the past four years as the 'airborne traffic situational awareness' (ATSAW) function. This may require operators to upgrade their existing traffic collision avoidance system (TCAS) to a new 'traffic computer', such as the Honeywell TPA-100A third-generation TCAS processor. TPA-100A will be able to actively track aircraft out to a range of 80-100nm, and it supports Mode-S-based ADS-B capability to extend passive tracking beyond 100nm.

For current A330s without the latest surveillance systems, Airbus is proposing a standard retrofit programme to upgrade the TAWS computers (enhanced ground proximity warning system (EGPWS) or T2CAS). This retrofit will enable them to use direct GPS data for aircraft positioning. This will ensure that the TAWS computer primarily uses GPS data for positioning the aircraft in latitude, longitude and altitude by blending the current air data/inertial reference unit's (ADIRU's) altitude and radio altitude with the GPS altitude. Airbus standard SBs are available for A330s already equipped with a TAWS computer.

Another navigation upgrade, an FMS landing system (FLS) feature, presents ILS-like vertical and lateral guidance on the primary flight display using the FMS computed position. This is also being adapted for the A330 flightdeck. FLS will enable autonomous non-precision approaches to airports not currently served by the traditional ILS. Certification is expected in 2009. Operators of older aircraft may need to upgrade to FMS2 release 1A standard, and ensure they have the latest Electronic Instrument System 2 (EIS2) standard cockpit displays and flight warning computer (FWC).

For precision approaches, the A330 may be upgraded with global navigation satellite system (GNSS) landing system (GLS) approach capability to allow

Various avionic upgrades are coming available that will give the aircraft increased surveillance power. This includes the ability to detect other aircraft up to 100nm away and display their position, heading and altitude and display it on a flightdeck screen.

The A330 has various structural modifications that relate to main landing gear bearing lugs, and inspection of cracks near to keel beem fastener holes.

operators to use destination airports with local area augmentation systems (LAAS). For both GLS and FLS, a Rockwell Collins multi-mode receiver GLU 925, certified mid-2008, is required to extend the use of satellite navigation from en-route and terminal operations to precision approaches.

Certification of GLS for precision Cat I approaches is expected in 2009, and precision Cat II & III approaches by 2015. Older aircraft may need to be upgraded to FMS2 release '1A' standard, and be equipped with the latest standard of EIS1/2, radio management panel (RMP), audio control panel (ACP), and FWC.

Another possible A330 avionics upgrade covers RNP with 'authorisation required' (RNP-AR) approaches as defined by the International Civil Aviation Organisation (ICAO). RNP-AR approaches allow reduced minima and provide an unprecedented flexibility in constructing approach procedures, such as 'curved flight path', including those with ground obstacles. These operations are area navigation procedures requiring the 'authorised' aircraft to have a specific level of performance and capability.

For an aircraft to be capable of such improved operation, the flight management guidance and envelope computer (FMGEC) must be equipped either with the latest Honeywell's FMS2 'P3' standard, or the Thales/Smiths FMS2 revision '2+' standard (available from 2009). A first RNP-AR step was certified for the A330 at the end of 2007 with the Honeywell FMGEC referenced above, with a performance accuracy of up to 0.1nm in approach and departure phases. In addition to the FMGEC, the aircraft's ADIRU, MMR, EGPWS and EIS2 must all be the latest standard. Carstensen says that for RNP-AR, only EGPWS version '965-1676-002' and subsequent versions are applicable, whereas T2CAS is not certified for RNP-AR.

A second RNP-AR step is to be certified by 2009 with the future FMGEC release 1A standards from Honeywell and Thales/Smiths. This will ensure a 0.1nm accuracy during missed approaches procedures.

Cockpit displays

Although Airbus introduced liquid-crystal displays (LCDs) in the A330/A340 (and A320 etc) with EIS2 standard from 2003, there does not seem to be a retrofit programme to replace the cathode-ray-tube (CRT) displays of the EIS1 standard in earlier models. However, Airbus says that the CRT displays can be changed on customer request via optional SBs.

Andreas Pakszies, director of aircraft system engineering at Lufthansa Technik, reports that it will upgrade all of Lufthansa's A330s with class-2 EFBs. "We will install a display module with a touch-screen function for each pilot, who will have a docking station for their EFB on the flightdeck. These docking stations will be linked together with cross-video and Ethernet. Lufthansa Systems will provide the software. The supplemental type certificate holder for this modification is Goodrich Sensor Systems.

"We are now in the qualification phase and are installing the provisions into our A330s. The first provision installation will be in May 2008, following one we have already carried out on an A340-600," adds Pakszies.

Structural modifications & ADs

About 100 airworthiness directives (ADs) have been issued on the A330, many of which also have equivalents on the A340. These ADs require structural inspections and modifications to be carried out. One notable example is Federal Aviation Authority (FAA) AD 2007-22-10, which details inspection of the main landing gear bearing lugs on wing rib-6. This requires an inspection every 300FC/1,500 flight hours (FH) for the A330-200 and 300FC/900FH for the A300-300. Other examples are AD 2007-09-09, replacing certain retraction links, and AD 2007-16-02, specifying the inspection for cracks adjacent to the keel-beam fastener holes at frame 40. This is related to SB A330-57-3081.

According to SR Technics (SRT) some of the most significant issues affecting the A330 aircraft are:

- SB A330-57-3088 and A330-57-3085, relating to crack propagation of the lower part of wing rib-6 aft aperture, between bottom skin stringers 18 and 20, extending from the lower edge of aperture in rib-6 to a fastener hole and then into the fuel pipe hole.
- A330-57-3082. This is the same rib-6 lug issue as detailed in FAA AD 2007-22-10 above.
- A330-57-3055. This Airbus SB, mandated by FAA docket no. 2001-NM-380-AD, covers the inspection and cold working of the wire harness slots in the inner rear spars of the wings between ribs -4 and -5.
- A330-54-3024 which replaces rib-18A in the pylon box structure.

SRT highlights Airbus's SB numbers A330-53-3152 and A330-53-3160, which both relate to rear fuselage reinforcement. SRT notes that while it has yet to perform these modifications on any aircraft, the impact in the future 'will be significant'.

Landing gear improvements

Operators have experienced problems with the landing gear, especially on earlier models due to stress concentrations in the top end of the main fitting, exacerbated by ground manoeuvres at high nose-wheel steering angles. Airbus removed from service the very earliest landing gears, 'D' and 'E' standard, and restricted the maximum steering angle. Newer

Pratt & Whitney is testing a more powerful variant of the PW4000-100; the PW4170. This will be rated at 70,000lbs thrust, have 1.2% lower fuel burn, and increased durability.

examples, 'F' standard, were replaced during routine 10-year heavy checks. Airbus has since reinstated the full 72-degree steering angle on newer landing gears, and those that have had the engineering rectification.

Pakszies says that the A330 landing gear originally had a life of 75,000FH or 50,000 flight cycles (FCs), based on an average FC time of 90 minutes. This is a particular issue for aircraft flying on long missions with a high hours-to-cycle ratio. For example, Lufthansa regularly flies its A330s on sectors of seven hours. "This meant we could not have the gears for a full second run after overhaul, because the FH limit forced us to remove them before we reached the second overhaul."

Airbus and Messier-Dowty introduced enhanced gears for the A330, with a new extended design goal of 125,000FH and 50,000FC. These gears have already been installed on Lufthansa's newest aircraft, and will last for the second period, thereby avoiding their removal during an intermediate layover (IL).

Trent 700 EP

Rolls-Royce provides a phased approach to upgrading the Trent 700 turbofan, referred to as 'Trent 700EP' (Enhancement Package). The first phase, available since 2007, covers a pocketless spinner fairing in front of the fan. Available later this year, Phase 2 will have: improved fan-tip clearance and turbine case cooling; and elliptical airfoil leading edges in the compressor section. Phase 3 in 2009 will introduce: improved blade tip clearance for the high pressure compressor (HPC), intermediate pressure compressor (IPC), high pressure turbine (HPT) and intermediate pressure turbine (IPT); a Trent 1000 style re-bladed low pressure turbine (LPT); and IPT nozzle-guide-vane re-profiled end-walls.

The original equipment manufacturer (OEM) says that the engine has benefited from continuous improvement, involving feeding back advanced technologies from newer members of the family. The HP module from the Trent 800 was incorporated into the Trent 700, resulting in longer on-wing life and performance enhancements. In addition, improvements are being fed back from the Trent 1000, including an LPT upgrade and improved fuel burn, to ensure the engine is the most fuel efficient on the A330.

'Tech CF6' upgrade

In 2006, GE launched the Tech CF6 programme to incorporate advanced technologies into the engine's HPT area. The new technologies include HPT airfoil cooling advancements to improve operational reliability and fuel burn retention, and lower maintenance costs.

From mid-2008, the Tech CF6 advanced technology will be standard on CF6-80E1 production engines. In September 2007, Finnair chose CF6-80E1 engines which are the first to incorporate the new Tech CF6 HPT upgrade.

The new HPT material, R88DT, via SB72-0186 will increase the engine's maximum exhaust gas temperature (EGT) redline limit (actual, not indicated) from 1,035°C to 1,050°C when coupled with an engine control unit (ECU) software upgrade. The R88DT HPT configuration includes enhanced blades (Stage 1 HPT blades with thermal-barrier coating (TBC) and Stage 2 HPT blades of 'DSR142' material). SB73-00422 and SB73-00433 raise the CF6-80E1A4's EGT redline limit from 1,045°C to 1,050°C.

PW4100 upgrades

For the PW4100 series, the OEM offers an upgrade to give an additional 20°C EGT margin, which involves installing ECU software version SCN6B. Later versions can provide maximum permissible EGT of 645°C actual (620°C indicated) for take-off, and 615°C actual (600°C indicated) for maximum continuous. The noted engine ratings and limits are controlled by EEC P/N and Engine Programming Plug (EPP) P/N, and are implemented by specific SB instructions. The engine data plate also reflects the engine rating.

Pratt & Whitney (PW) is testing a more powerful PW4170 variant, 'Advantage70' for service entry in 2009. As well as increased thrust, this model is expected to deliver 1.2% lower fuel consumption, increased durability, and a reduction of 20% in operating costs. It will also be available as a retrofit to earlier standard engines. Flyington Freighters, the launch customer for the A330-200F, chose 'Advantage70' PW4170s to power these aircraft, which are due to enter service in late 2009.

The PW4000 upgrade includes a new HPC ring case to improve reliability and reduce fuel consumption. There is a new second-stage HPT vane, and improved thermal barrier coatings with half the conductivity of the current material. The first stage vane is strengthened for longer life, and the turbine will be fitted with more durable outer seals. Durability will be increased by an improved TALON II combustor. Software enhancements to the FADEC will be offered, allowing pilots more flexibility in take-off and climb thrust power to better match engine thrust with specific flight requirements.

An upgrade to the diagnostic engine management will better analyse engine performance data, providing input for more effective maintenance planning. PW will certify this upgrade package with the FAA in 2008, and all production engines will subsequently be delivered to this higher standard. Upgrade kits for in-service engines will also be available for incorporation at the next heavy maintenance shop visit. AC