

Despite powering about half the A320 family fleet, there are a limited number of providers for shop visit maintenance and specialist parts repairs for the V2500. Although the V2500 support market will grow, supply in the market is expected to remain tight.

Who's who in the V2500 family support market

The V2500 is manufactured by International Aero Engines (IAE), a joint venture (JV) originally between five companies, hence the V in the engine's name. The four current shareholders are: Pratt & Whitney (PW), with 32.5% of the shares; Rolls Royce plc (RR), also with 32.5%; The Japanese Aero Engines Corporation (JAEC), with 23%; and MTU Aero Engines (MTU), with 12%.

The V2500 engine is the second engine option on the A320 family, and powers 1,730 aircraft (3,460 engines) in current operation. There are also 218 engines powering the MD-90. Including spare engines and retirements, the total number of V2500s manufactured currently stands at over 4,000 units.

According to Nicola Whale, V2500 programme manager at Total Engine Support (TES), there is a limited market

for spare V2500 engines. IAE tightly controls the market to ensure that all operators have spare engines available in case of unexpected or lengthy shop visits. TES says it would therefore struggle to lease out any V2500 spare engines, even if they had some available to place. Operators do not need to lease spares from the market to cover shop visits.

V2500 fleet

The V2500 fleet comprises 3,678 engines (fitted to A320s and MD-90s) of which just 2% are parked, so there is a large active fleet that needs regular shop visits. Over 30% are in the Asia Pacific region, backed up by the large number of maintenance, repair & overhaul (MRO) facilities there that have V2500 engine shop capability. This is true also of Europe and North America, where 25%

and 23% of the global fleet is operated respectively. These figures mirror the locations of the IAE shareholders.

There are three main variants: the V2500-A1, the V2500-A5 and the V2500-D5.

The V2500-A1 is the original and oldest version of the engine, with all examples being at least 16 years old. It now powers 124 A320-200 aircraft (of which 26 are currently parked), although 362 -A1 engines were originally manufactured until production switched to the -A5 in 1994 (see *Owner's & Operator's Guide: V2500, Aircraft Commerce, February/March 2008, page 10*). There are 90 V2500-A1s in the Asia Pacific, with the next largest fleet in South America (29 aircraft). As the first version, the -A1 had suffered from a number of teething problems, but once an upgrade of the -A5's hot section (known as the Phoenix Standard) became available, the variant's on-wing life was extended and maintenance costs reduced. Replacement was therefore not an issue. Older engines will have matured and completed at least two major shop visits.

There are nearly 1,900 engines currently on order, all of which are V2500-A5s.

MRO market

The V2500's maintenance requirements will depend partly on the rate of utilisation by operators, the engine flight hour (EFH) to engine flight cycle (EFC) ratio, and the typical removal and

The V2500 shop visit market is about 800 shop visits per year. With outstanding orders and fleet growth this is forecast to grow to 1,300 annual shop visits by 2018.



V2500 GLOBAL FLEET CURRENTLY IN OPERATION

Aircraft Variant	Africa		Asia Pacific		Europe		Middle East		N. America		S. America		Aircraft sub-total
	Active		Active	Parked	Active	Parked	Active	Parked	Active	Parked	Active	Parked	
V2500-A1	16		90	8	30	10			28	6	58	2	248
V2522-A5	22		30		92				110				254
V2524-A5			128		92		12		130		120		482
V2525-D5			86		14	2			4	2			108
V2527-A5	20		476	2	340	24	96		488	6	96		1,548
V2527E-A5	8		44		30	2			8		76		168
V2527M-A5			44	2	12	2	10	2			26	2	100
V2528-D5			8	6			56	2	38				110
V2530-A5			40	2	72								114
V2533-A5	8		220		212	6	40		40		20		546
Geographical sub-totals	74		1166	20	894	46	214	4	846	14	396	4	3,678
	74		1,186		940		218		860		400		3,678

shop visit intervals achieved by the engine. Lufthansa Technik Airmotive Ireland (LTAI) estimate that a heavy shop visit will cost \$2-3 million, depending on the life limited part (LLP) profile required. It is the number of LLP replacements during a shop visit that can increase the overall price.

Sourcing maintenance

A limited number of engine shops offer different types of V2500 repair and overhaul capability, varying from basic disassembly into modules to the most detailed and complex component repairs.

Information relating to the capability of each facility is divided in two parts.

The first part is the main engine level, which can be as simple as disassembling the engine into modules, disassembling each module to piece-part level and completely overhauling the module. The engine's six main modules comprise: the fan and low pressure compressor (LPC) assembly; the high pressure compressor (HPC); the high pressure turbine (HPT); the low pressure turbine (LPT); the combustor; and the gearbox.

The survey results summarise the capability level of each shop for each of these modules. There is a table for each module, and each shop's capability with respect to that module (see tables page 54). Three main levels of capability are listed: minimum (M), refurbishment (R) and overhaul (O). These are the same workscope levels as defined in the workscope planning guide. A minimum workscope involves a simple external inspection and a borescope. Refurbishment involves some degree of disassembly and inspection, but the module is not completely disassembled to piece-part level, and some repairs will be carried out. An overhaul involves a complete disassembly of the module to piece-part level, and an inspection of all parts, and repairs. If the shop lacks the required capability for an overhaul, the work is sub-contracted, which is denoted by S.

The second part of the article concerns specialist and high-technology repairs of piece-part components.

Shop module capability

All the main global V2500 engine shops were consulted for this survey, and their module and main engine maintenance capabilities are listed (see tables, page 54). The main shops are those operated by the original equipment manufacturers (OEMs): PW, RR and MTU. There are also a few independents and shops connected to an airline.

The OEM shops generally offer a complete overhaul service with disassembly of all modules to piece-part level, and then complete repair of these parts. Other shops, such as Lufthansa Technik (LHT) also offer full overhaul capabilities while at the other end of the scale some smaller shops, such as EgyptAir Maintenance & Engineering, concentrate on certain areas of an engine and send other modules away to specialist shops.

The main maintenance provider is one of the OEMs. MTU Maintenance alone accounts for one-third of annual engine shop-visit activity for the V2500. Its market share is due to three reasons: it is an OEM; it is capable of carrying out all engine module breakdowns and repairs; and it has facilities in the two most popular locations for the V2500 (Asia Pacific and Europe). In addition, MTU Maintenance carries out work to all three shop-visit levels as well as specialist repairs.

PW has four main facilities covering North America, Europe and Asia Pacific which together undertake just over 14% of the annual shop visits. It also has a number of smaller component facilities. The European facility, in Turkey, is a recent joint venture (JV) with Turkish Technic, while the two facilities in Asia Pacific are a JV with Air New Zealand and a JV with Singapore Airlines. An additional East Hartford facility maintains line replaceable units (LRUs).

RR has two facilities in Europe and North America. Together the two facilities undertake nearly 8.5% of the shop-visit market.

The final shareholder in the V2500's development, JAEC, has no obvious share in the engine's maintenance. However, IHI Corporation, which is a partner in JAEC, does maintain the the V2500 and its modules, and carries out 5% of engine shop visits.

As happens with many other aircraft and engine types, the largest airline maintenance facility is Lufthansa Technik (LHT) with just over 11% of the engine shop-visit market. LHT's main facility is at Hamburg, although the V2500 is also maintained at LHT's Lufthansa Airmotive Ireland. In addition, some LRU and thrust reverser maintenance is undertaken at Lufthansa Tech Composite Tulsa.

There are a few smaller maintenance providers, both airline-connected and independent. As the A320 fleet, and therefore the V2500 engine fleet, grows, so too should the number of maintenance providers. A number of large A320 airframe MRO facilities in time may choose to undertake more and more engine shop work. Alternatively, as the V2500 support market is tightly controlled by IAE, there may be more JV facilities between the OEMs and airlines. Some airlines still choose to maintain their engines in house, although they do not offer this as a third-party service. These represent nearly 4% of the global market. With the limited spare engine market and a growing A320 fleet, it makes sense for those facilities that already deal with the A320 to undertake engine maintenance. Further development into engine work may be considered by large A320 maintenance providers such as SR Technics and ST Aerospace.

Africa

There are currently only 74 V2500 engines in Africa, all of which are in active operation. This represents only 2% of the global fleet. The major facility with



engine shop capability is EgyptAir Maintenance & Engineering, which carries out 1% of annual shop-visits.

South African Airways, which operates 22 V2500 engines (and has an order for 30 more) contracts out all its engine maintenance, with the V2500 contract currently up for tender. As the A320 ages and airlines update their short-haul fleet, many older A320 aircraft and their V2500 engines may make their way to Africa. If this were to happen the number of support providers would need to increase, since there is just one major facility in North Africa.

Asia Pacific

About one-third of the global V2500 engine fleet is operated in the Asia Pacific, making it the largest fleet, although just a quarter of shop visits are carried out there.

The main independent MRO facility is also connected with an OEM, and is the most prolific V2500 maintainer of the region. MTU Zhuhai has over 11% of the global shop-visit market. Evergreen Aviation Technologies Corporation (EGAT) is also a busy independent taking 3% of the global market. EGAT used to be EVA Air's maintenance and engineering division but it has been totally independent since 1998.

IHI is a Japanese industrial equipment manufacturer that also maintains 5% of the global V2500 shop visit market. It is an independent but, as part of the JAEC consortium, it is an OEM like MTU. Of the other shareholders in IAE, RR has no facility in the Asia Pacific specifically dealing with the V2500, while PW has Eagle Services Asia (a JV with Singapore Airlines) and P&W Christchurch Engine

Center (a JV with Air New Zealand). This latter facility, together with Air New Zealand Engineering Services (ANZES), accounts for nearly 4% of global V2500 shop visits.

A number of airline-connected maintenance providers have engine shop capabilities within this area. Some are JVs with OEMs, or have since gained independence like EGAT. Others are still airline-connected MRO facilities (not necessarily offering third-party ability) that have capabilities anywhere from module disassembly to being a one-stop shop. Examples include Singapore Airlines' SIA Engineering Company and Air India. GAMECO has been formed by a JV between China Southern Airlines and two other companies to maintain China Southern's engines.

Nearly 800 new engines are expected to be delivered to the area over the next six years, representing nearly half of all new deliveries. It is therefore likely that the area's capability, both in shop capacity and numbers, will increase.

Europe

Europe operates a quarter of the global V2500 fleet, with a number of MRO facilities catering for these engines. At least another 300 engines will be delivered over the next six years.

The IAE shareholders are well represented with MTU Maintenance's large facility in Hannover, which carries out nearly 21% of global shop visits.

RR has a facility in East Kilbride, Scotland which completes nearly 8% of global engine work. Its customers include British Airways and Monarch Airlines.

PW also has one European facility, with a 2.5% share of the market. Located

The majority of shops with V2500 capability are related to the engine's four OEMs. In addition, there are a few airline-related engine shops.

in Turkey, P&W Turkish Technic Engine Maintenance is, as the name suggests, a recent JV with Turkish Technic. The current market share comes in part from those engines maintained by Turkish Technic itself, although it is possible that the new JV's share will increase due to its location and increasing ability to specialise and offer PW expertise.

There are no major independent facilities in Europe catering for the V2500, although there are many airline-related facilities that offer capability on the A320 and may wish to add the V2500 to their list of engine capabilities, especially those that already deal with the CFM56-5. PWA International in Ireland has some V2500 overhaul capability, as does 1-Source Aero Services in Greece, Nordam, Goodrich and Chromalloy.

The largest airline-connected MRO facility is LHT in Hamburg with over 11% of the global market. LHT is truly a one-stop shop, with additional capability at Lufthansa Airmotive Ireland (LTAI). LTAI aims in coming years to have average turnarounds of 45-50 days while they forecast 20 shop visits for 2010, rising to 40-50 over the next three years. LHT has contracts with large operators in Europe, including Aegean Airlines, bmi, Wizz Air as well as a number in the Middle East.

Middle East

Just 6% of the global fleet of V2500 engines are operated in the Middle East, with additional orders currently standing at 128 units.

The major operator in this region, Saudi Arabian Airlines, overhauls its engines in-house. Another large operator is Qatar Airways with 25 aircraft (50 engines) which uses LHT (as well as MTU Hannover) in Europe. This works for Qatar Airways, since Europe is a big part of its route network. Etihad and Royal Jordanian also have engines going to LHT, with the former also having a new contract with RR East Kilbride for shop visits.

A few facilities, like Bedek Aviation (a division of IAI), Jordan Airmotive and Alsalam Aircraft Company, do component work. Some airline engineering departments also carry out component work, but few have full overhaul capability.

V2500 MAIN ENGINE SHOP CAPABILITIES

Maintenance Provider	Intermediate case (Fan case & frame, internal gearbox & stub shaft and booster stage bleed valve)	Fan rotor	LPC	HPC	Diffuser (Comburator and No. 4 bearing compartment)	1st Stage nozzle	HPT	LPT	Turbine exhaust case	Gearbox
EgyptAir Maintenance and Engineering	M/S	M/S	S	O	O		O	S		S
Evergreen Aviation Technologies Corp.	M/R/O	M/R/O	M/R/O	M/R/O	M/O/S	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O
IHI Corporation	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O
Lufthansa Technik	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O
Lufthansa Technik Airmotive Ireland	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O
MTU Maintenance Hannover	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O
MTU Maintenance Zhuhai	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O
P&W Christchurch Engine Center	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O
P&W Columbus Engine Center	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O
P&W Turkish Technic Engine Center	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O	M/R/O

In-house Shop visit levels
M - Minimum
R - Refurbishment
O - Overhaul
S - Module sent away

North America

The third largest fleet is in North America, which has 23%. An additional 468 engines are currently on order.

The main engine shop in North America is P&W Columbus Engine Center, which carries out over 8% of the global shop visits. Its only capability is for the V2500. Of the OEMs, RR is the only other company to have a facility in North America. RR Canada carries out a small number of shop visits on the V2500, with just a 1% market share.

North America may not have as many full overhaul facilities as its share of the global fleet would suggest, but it does have a large number of companies that manufacture and/or repair & overhaul engine components. These include Patriot Aviation Services and Complete Turbine Service.

North America has many very large operators of the V2500, but most have their shop visits carried out by facilities on other continents. United Airlines, the largest global operator with 152 V2500s, contracts its shop visits to P&W Columbus Engine Center, but all other large US operators send the engine to MTU Maintenance Hannover or EGAT.

South America

There are 400 V2500 engines in South America, with 132 currently on order. Destinations include 30 for LAN Airlines, 36 for TACA International

Airlines, 40 for Volaris and 22 for TAM Linhas Aereas.

Despite having just over 10% of the global fleet, South America has no major engine shops, although Goodrich carries out thrust reverser work in Brazil. V2500 engines based in South America travel to other continents for shop visits, with TAM Linhas Aereas using MTU Maintenance in Hannover, for example.

Overview

It is only recently that the A320 has been seen as a partly ageing fleet. Those A320s that are reaching 20 years are likely to be retired from their original operators' fleets and moved to developing economic regions, meaning a potential development of engine shops in that area.

The V2500-D5 that powers the MD-90 is also an older version of the engine, and plans have long been in the pipeline by some of the larger operators, such as Saudi Arabian Airlines and China Eastern, to retire them (*see V2500 aftermarket & values, Aircraft Commerce, February / March 2008, page 36*). As these aircraft change location, more engine shops may be required elsewhere. Taking out the few MD-90s from the fleets of the Middle East and Asia Pacific will not affect shop needs there, since their A320 fleet is growing at a faster rate.

"The market for the V2500-A1 and -D5 is shrinking," says Stuart Hatcher, head of valuation and modelling at The

IBA Group. "Values have dropped in both cases and now you are expecting to see -A1 values below \$3 million for a half-life mature engine, and -D5s closer to \$2.5 million." With a shrinking market there will be limited shops that can maintain their capacity.

While it is likely that the main engine shops of the OEMs and LHT will retain their market share, other shops have an opportunity to increase their share as the V2500-A5-powered A320 fleet grows.

Engine removals

Removal intervals can vary depending on many different factors. These include average sector (flight time) length, thrust rating, operating base temperatures, engine variant and age of the engine. The older the engine, and the hotter the main location, the more likely the intervals will be reduced. According to TES, an interval of 19,000 engine flight hours (EFH) or 9,000 engine flight cycles (EFC) can be seen on a low thrust V2500 before its first shop visit. A high-thrust engine operates for 12,000-14,000EFH or 6,500-7,500EFC before the first shop visit. Intervals are reduced by 2,000EFH or 1,000EFC for the second shop visit for low-, medium- and high-thrust rated variants.

"For the most common variant, the V2527, first intervals are generally 10,000EFC with a second interval of 8,000EFC," says Hatcher. "But this is limited by exhaust gas temperature

ANNUAL V2500 SHOP VISITS

	2008	2009	2010F	2014F	2018F
V2500-A1	126		70	615	640
V2500-D5	86		50		
V2500-A5	476		670		
Total	688	734	790	1,000	1,300

Source: Aerostrategy OAG (2008) and MTU Maintenance

(EGT). Costs will be \$2 million for the first run and \$2.25 million plus for the second. The -A1 runs 1,500-2,000EFC shorter than the V2527 on the same routes”.

The lower-rated V2522 and V2524 are very rarely driven off-wing by EGT margin. It is usually the hardware condition of the HPT that dictates the removal, especially deterioration of the first stage HPT blades and vanes, which Whale says is picked up on a borescope, forcing removal. Hatcher agrees that these engines are usually unable to reach the full 20,000EFC LLP limit, since it is prudent to pull the engines off-wing after about 14,000EFC to prevent distress.

This is echoed by Matthias Wagner, chief engineer V2500 at MTU Maintenance Hannover, who says that typical shop visit intervals do not exactly match the LLP hard life limits, especially when cost-effective fleet management involves smart shop-visit staggering and some hospital shop visits. Assuming average EFC lengths of 1.5EFH, Hatcher says the second run would be 11,000-12,000EFC.

“The V2500-D5 tends to have lower EFC lengths and achieves average intervals of 9,000EFC,” says Wagner. “Generally the engine, depending on thrust rating and operational environment, varies from 5,000 to 12,000EFCs. V2530 and V2533 engines power the A321, and have shorter intervals because of EGT degradation due to high thrust and sector length. LLPs therefore don’t need to be replaced until the third visit. With average FC times of 2.5FH, the V2530 will last 8,000EFC before its first shop visit and 6,000EFC until its second. The V2533 can expect intervals of 6,000-7,000EFC and 5,000EFC between its first and second shop visits. Costs will be closer to \$1.8 million for the first run and \$2 million for the second run (excluding LLPs), since the intervals are so much shorter.”

Every shop visit will involve a hot section restoration and performance workscope, with the core refurbishment and full performance restoration alternating each visit. The LPT and LPC will be overhauled at every second or third shop visit (depending on the time

since the last shop visit, its condition and any LLP expiration).

Generally, an environment such as desert operations could result in more frequent shop visits (8,000EFH), due to combustion chamber burning and HPT 1st blade distress. Although a low thrust engine used for medium-range non-desert operations could get as much as 24,000EFH between shop visits, the most likely reasons for such an engine to be removed are LLP replacement, HPC stage 3 blade clapper wear, HPC lockplate losses and unforeseen damage, from foreign objects, for example. Whale says that high thrust engines are also likely to see removals due to a reduction in EGT margins. The deterioration rate is about 4 degrees per 1,000EFH with an EGT margin of around 50 deg C.

Component repairs

There are a number of specialist repair providers for the V2500 engine family. To examine the services that are provided by these companies, the different modules, sub-structures and main components of the engine are taken into consideration. There are, however, a few providers that offer repairs for virtually all components on the engine. MTU, PW and RR all have large parts repair capabilities at both their main facilities and at smaller support shops.

Besides the OEMs, Lufthansa Technik is the airline maintenance and engineering organisation with the largest engine component repair capability. Its main engine shop is at Hamburg, but it also has Lufthansa Technik Airmotive Ireland in Dublin for engine disassembly and module maintenance.

Engine modules

As well as the extensive abilities of the major MRO facilities, there are many companies that overhaul and repair parts of an engine’s module, such as blades, vanes and stators for the LPC and HPC. Chromalloy is one of market leaders in such repairs.

The combustion chamber and its component parts are another section of Chromalloy’s business. In addition,

EDAC Aero Rotating Components in the United States overhauls and repairs major rotating and life limited rotating components such as the turbine and compressor airseals, LPT and HPT shafts, and LPT, HPT, LPC and HPC discs. Repair is a better option, since catalogue prices, according to TES, can range from \$27,200 for a rear rotating seal to \$199,750 for a stage 1 HPT disk. Various repair methods are used at EDAC, including knife-edge restoration, snap diameter restoration, chrome plating and HVOF plasma repairs. They also carry out borescope inspections.

Combustor Airmotive Services Pte Ltd (CAS) is a JV between SIA Engineering Company and PW, which undertakes complete overhaul of combustion chambers and fuel nozzles on the V2500.

The HPT module requires some of the most expensive and advanced repairs, such as laser drilling on the blades and nozzle guide vanes. LHT and LHT’s Lufthansa Technik Intercoat have developed a thermal barrier coating for the V2500 combustion chamber fuel nozzle guides. LHT says it is more comprehensive than the OEM’S, and that to prevent early deterioration with cracking and oxidation of the outer ring, it has also developed a special repair method to restore the damaged nozzle guide, avoiding the cost of a complete fuel nozzle guide replacement. It believes the two processes will substantially extend the service life of a repaired component beyond that of a new part.

Aero Gear is a company in Connecticut that specialises in the repair and overhaul of various parts of the V2500 gearbox. All the OEMs, as well as LHT, undertake this work, as do ANZES, Bedek and Gameco. In the United States, Twin Manufacturing and Air Concepts Repair also repair gearbox components.

LLPs

LLPs can be broadly divided into three categories: shafts, discs and rotating airseals.

As well as capabilities offered by the OEMs and main engine shops, there are many parts repairers, such as EDAC Aero Rotating Components, that do not undertake full engine overhaul but specialise in the repair & overhaul of LLPs. EDAC also manufactures parts for some engines.

Component Repair Technologies in the United States repairs engine shafts, and its capabilities include analytical testing, cleaning, dimensional inspection, heat treatment, machining, non-destructive tests, plating, surface treatment, thermal spray and welding. Also in the United States, Air Concept Repairs undertake, among other components, the LPT shaft. With an LPT

Providers of specialist and hi-tech OEM-approved parts repairs include MTU Maintenance, based in Hannover.

shaft costing \$77,770, repair is an important factor.

Cases & frames

Cases and frames are some of the simplest parts, being non-rotating and having no moving parts. Chromalloy and Air Concept Repairs repair all or some types of V2500 cases. Air Concepts Repairs does the fan case and cone, while Chromalloy repairs cases and frames at San Antonio, TX.

Accessories & LRUs

The main components mounted on the outside of the engine can be divided between accessories and quick engine change (QEC) components.

It seems that most, if not all, V2500 engine overhaul facilities are capable of Accessory and LRU repair. In addition 1-Source Aero Services in Greece, Airfoil Services in Malaysia, Auxitrol in France and Saywell International in the United Kingdom all undertake some repairs. In the United States there is Accel Aviation Accessories, GKN Aerospace, JFJ Industries, PAS Technologies, TCI, Triumph Accessory Services, Twin Manufacturing, Westfield Gage and Woodward Governor. Chromalloy has capabilities at both its Texas and Holland facilities.

Nacelles & thrust reversers

As with many of the V2500 components, the major engine shops have nacelle and thrust reverser capability, but there are also a number of companies that specialise in this area.

Goodrich is a manufacturer and overhauler of nacelles for a number of different engine types and its capabilities include the thrust reverser. The V2500 nacelle is overhauled at seven facilities in the United States, United Kingdom, Brazil, United Arab Emirates, France and the Asia Pacific.

Bombardier's facilities offer an enhanced overhaul capability on the V2500's nacelles. The nacelle's inlet cowl acoustic panels comprise a composite sandwich structure covered by steel wire mesh. The panel is stripped back to the backing tray and built up again using a process which ensures the component's structural and acoustic integrity is



restored, and the panel is fully functional again at a fraction of the cost of replacing it.

Working with Bombardier in Belfast, Goodrich have developed a lightweight fan cowl design which will be manufactured in Goodrich's Alabama facility.

Other facilities include Airframe Components Europe, Alsalam Aircraft Company, First Wave MRO, Gameco and Triumph Airborne Structures.

PMA parts

PMA parts are non-OEM manufactured parts that have been certified by the Federal Aviation Administration (FAA) as suitable alternatives. Unsurprisingly, IAE does not recommend PMA use, and says they will reduce the residual value and marketability of the engine.

The list price of PMA parts can be as much as third lower than that of OEM parts, according to LTAI and EGAT, which also comment that PMA development is just in its infancy. They expect to see airfoils for the V2500 available by the end of 2010. MTU Maintenance agrees that the PMA market share for the V2500 is low compared with other engine types. It recognises some growth over the past 1.5 years, although this remains negligible and confined to lower value parts. The development and use of PMA parts will be limited, because nearly 80% of shop-visit capacity is with IAE shareholders.

Modifications & upgrades

In previous years, many removals were due to clapper limits on the HPC

stage 3 blades, says Whale. The blade has been modified, however, so it is now more resistant to wear. With 80% of the fleet having now installed the modified blades, removals for this reason have reduced. Whale says another removal reason was related to fracture of the stage 6 HPC blades, but 60% of the fleet has now had modified blades fitted. These have a 70% improved material strength that is also more resistant to impact and airfoil damage.

The Phoenix kit is an upgrade for the V2500-A1, and has been available since December 2000. SelectOne is available on new engines, or in conjunction with an IAE overhaul contract. This upgrade aims to lower costs by extending on-wing time and reducing fuel burn. This means that newer engines will not need shop visits as often, but older engines will have an increasing need. The average number of shop visits per year will still slowly increase as the fleet increases.

PW has introduced a new design of engine, the Geared TurboFan (GTF) PW1000, which is aimed at the narrowbody short-haul market. This will be a direct competitor for the V2500 when engines are chosen for new aircraft. This could mean further developments and upgrades to the V2500 to increase both its efficiency and thrust. The new PW engine, as well as the PW6000 being available for the A318 and not the V2500, could also see a strain in the IAE partnership. Despite this, the engine will continue to be operated on the A320 family and with a healthy number on order, the fleet will continue to grow. **AC**

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