

Hi-tech parts repair is the highest level of engine maintenance. Hi-tech repairs take a long time and high investment to develop. Few engine shops offer a high level of hi-tech repairs. How are hi-tech repairs developed, and which shops have the highest levels of capability?

# Engine hi-tech repair capability survey

Capabilities of engine shops which offer services for the same engine model vary widely, with several levels of engine maintenance available. There are several hundred hi-tech repairs for each engine type, but few engine shops have the capability to offer most of them. Which engine shops have the highest levels hi-tech repairs, and how do engine shops acquire the capability to offer them?

## Engine maintenance process

The engine shop visit process can be split into different levels.

“The first type of engine maintenance is routine work, and includes disassembly, inspections and diagnostics, cleaning, reassembly and testing,” explains Jean-Luc Doublet, vice president of industrial operations at Snecma Services. “In parallel to routine work there are parts repairs.”

The first stage of CFM56 maintenance is to disassemble the engine into its three major modules and remove the accessories. Some other engine types have a different number of major modules. The second stage is to split each major module into minor modules.

“Minor modules then have to be disassembled to piece-part level,” says Doublet. “The third level is disassembly of minor modules into piece part level and also includes light repairs. It is then determined whether parts should be kept, repaired or scrapped. It is also decided how parts should be repaired, or if cheap replacement parts can be used.”

## Levels of parts repair

The fourth level of engine maintenance is parts repair, to which there are three different levels. Diagnostics are performed to check various criteria, such as cracks and dimensions. “There are three possibilities at this stage,” explains Doublet. “Parts

can be found to be serviceable, they can be repairable (if a repair already exists or needs to be developed), and if there is no repair or it is beyond economic repair it is scrapped.”

Parts can be acquired either as new from the original equipment manufacturers (OEMs) or from suppliers of parts manufacturer approval (PMA) parts, or as used serviceable items.

Repairable parts need an appropriate repair shop. “Simpler repairs are described in the engine shop manual,” says Doublet. “Light repairs, such as the rectification of scratches are the simplest. The next level is general repairs, which includes items such as grinding and plasma spraying.

“The highest level of part repairs, hi-tech repairs, is sourced-approved repairs, which are approved by the OEMs, or repairs approved by a Designated Engineering Representative (DER) of the Federal Aviation Administration (FAA),” says Doublet.

Examples of hi-tech repairs are electronic beam welding to damaged fan blades or laser drilling of high pressure turbine (HPT) blades. These repairs are sophisticated and require a lot of process control. Approval is required for them either because the part is critical, or the repair is hi-tech.

## Parts classification

New parts can either be acquired from the OEMs or from PMA suppliers. “PMA parts are those made by manufacturers which have FAA approval under FAR 21, and are an alternative to buying direct from the OEM,” explains Wolfgang Weynell, director customer support and product management powerplant overhaul at Lufthansa Technik. “PMA parts are on average 25-30% cheaper than OEM items, the prices of which have increased significantly over the past 10 years. HEICO is an example of a PMA manufacturer. It is possible to

save tens of thousands of dollars a year by using PMAs, and they last as long as OEM parts. The FAA makes PMA and OEM parts interchangeable, and they have an interchangeable part number. Source-approved and DER repairs developed for OEM parts can then also be used for the same PMA part. Source-approved repairs have an advantage, since they are mentioned in engine shop manuals, while DER approved repairs are not.”

## Approval process

Few engine shops, other than OEMs, have a high level of source-approved repair capability.

In addition to engine shops and OEMs, hi-tech repairs are performed by specialist engine repair companies, such as SIFCO, Chromalloy, Praxair and Sermatech. These companies were the traditional providers of hi-tech repairs, before OEMs expanded their aftermarket maintenance activities.

“Some specialist repair agencies and independent engine shops develop their own repairs using reverse engineering,” explains Doublet.

MTU is a major independent engine repair shop, and has capability for the CF6-50C2/-80C2, CFM56-3/-7, V.2500, PW2000 and CF34. “We want to keep the maximum level of repairs in-house, since this allows us to control turn times and make money,” says Lothar Bodenburg, director of marketing at MTU. “While we have OEM-approved repairs we also have the capability to develop repairs approved by the FAA and Joint Airworthiness Authority. We do have difficulties in getting source-approved repairs, and we have to ask our customers if they will accept FAA/JAA approved repairs. Our prime goal is to co-operate with the OEMs. It can be expensive, however, to get licences for source-approved repairs.”

Source-approved repairs are complex

*Most engine shops have the capability to fully disassemble engines to piece part level, and perform diagnostics, light and general repairs on parts. What distinguishes shops with high capabilities are their ability to offer source-approved and DER FAA parts repairs. Shops that do not offer hi-tech repairs sub-contract them to those that do offer them.*

in nature and require OEM quality approval, or use proprietary and confidential information protected by patents. "Source-approved repairs are usually developed between OEMs and preferred suppliers or engine shops with specialist capabilities. Other engine shops develop their own repairs and then seek approval from the OEM to support their application from the airworthiness authority," explains Bob James, operations director at Total Engine Support. "OEMs normally only source-approve enough repair shops to satisfy market requirements, so the market does not open up to competition."

Shops submit repair techniques, sometimes together with a supplier, and an application for OEM approval to support certification by the FAA. Sample repairs are sent to the OEMs for testing. "Factors such as the effect on new part sales, probable remaining on-wing life of the component and reliability are considered," explains James. "It can take between a few months and several years to get a source-approved repair. Examples are HPT vane replacements, weld repairs to knife-edge seals, compressor tip welding and fan blade patching. The number of hi-tech repairs for each engine type can be up to a thousand or more."

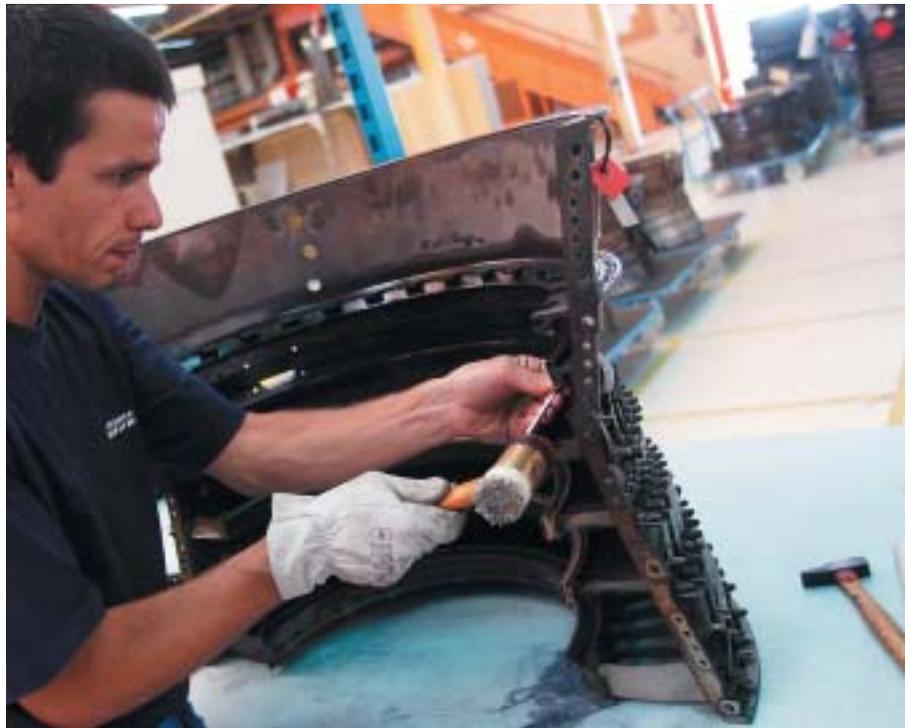
Engine shops must pay OEMs royalty fees based on the number of repairs performed each year, as well as an up-front fee for initial approval.

MTU provides an example of the long-term process of developing repairs. "We started developing repairs for the CF6-50 in 1981 and it has taken us 10 years to get to a level of offering 90% of all hi-tech repairs for the engine," says Bodenburg.

## Economics of repairs

The development of these repairs affects on-going engine maintenance costs, and parts repairability has a large influence on maintenance costs per engine flight hour.

"It may become harder for engine shops to get source-approved repairs, so the number of in-house DER repairs has to be increased," says Weynell. "Prevention of scrapping by introduction of more repairs, the use of PMA parts and the purchase of surplus material will also reduce material consumption and cost. For example, a new nozzle guide



vane costs about \$18,000, compared to a repair of about only \$2,000." Other disadvantages of having a low in-house repair capability are that a shop depends on specialists, and parts often have to be exchanged with an associated cost increase to meet the turn times. It is not economically justifiable to have 100% repair capability for an engine. Lufthansa Technik is, for example, the only shop in the world to have developed a re-contouring repair for CF6 and CFM56 compressor blades, and these repairs were approved by the OEM."

## Source-approved vs FAA DER

While the quality of FAA DER repairs may be similar to source-approved repairs, OEMs will not accept warranty claims from airlines for parts that have been repaired using FAA DER techniques. The OEMs feel happier if airlines use OEM-approved repairs because of warranty issue.

Lufthansa Technik does not think warranties are affected by using FAA DER repairs or PMA parts. "We therefore go straight for FAA approval together with JAA approval to meet our customers' demands," says Weynell.

## Engine shop capabilities

Engine shops can broadly be subdivided into three categories: the OEMs; independent shops; and airline shops.

This survey considers major engine shops in the third-party engine maintenance business for engines powering jetliners. Shops operated by large carriers, such as Northwest and American, are therefore not considered.

## OEMs

The OEMs include General Electric (GE), Pratt & Whitney (PW), Rolls-Royce (RR), Snecma Services and Honeywell.

Many of these have increased their hi-tech parts repair capability. OEMs now generally have the highest levels of source-approved repair capabilities, although they still sub-contract some repairs to specialist, hi-tech repair providers.

GE Engine Services (GEES) has three shops in the US, two in Brazil, one in China, two in the United Kingdom and one in Malaysia (see table, page 26). It offers maintenance services for engine types including: CF6-6/-50/-80A/-80C-80E, CFM56-2/-3/-5A,B,C/-7, CF34-3/-8, GE90, PW4000 and RB211.

GEES's capabilities include all levels of maintenance up to light and general parts repairs for all the engines types it handles (see table, page 26).

GEES has hundreds of source-approved repairs for all CF6 series models, all CFM56 models, the CF34-3/-8 and GE90, which are all models that it manufactures for civil jetliners. It does not, however, offer source-approved repairs for its competitors' engines, the PW4000 and RB211.

PW Engine Services (PWES) has five engine repair shops: two in the US; one in Stavanger, Norway; a joint venture with Singapore Airlines Engineering called Eagle Services Asia in Singapore; and a joint venture with Air New Zealand in Christchurch (see table, page 26).

Its Columbus, Ohio facility has full capability for the V.2500-A1/A5/D5, JT8D and JT8D-200, but uses its global



network of parts repair facilities for hi-tech repairs.

Its Cheshire, Connecticut facility offers maintenance up to piece-part disassembly and light repairs for all models of the PW4000 family, all models of the JT9D family and PW2000. It uses its network of facilities for general and hi-tech repairs for these engines.

The Eagle Services Asia plant performs maintenance for the PW4000-94/-100, JT9D-7R4/-7Q and CFM56-5C up to light component repair level, and then uses its global shop network for general and hi-tech repairs.

Its Christchurch facility offers all levels of engine maintenance for the JT8D and JT8D-200 series. This includes some hi-tech repairs.

Rolls-Royce (RR) has an extensive network of engine maintenance shops and several joint venture shops.

Its main engine shops are at Derby and Glasgow, United Kingdom. The Derby facility has capability for all RB211 and Trent models, while Glasgow is for the Tay and V.2500. Both of these facilities have some hi-tech repairs. Some hi-tech repairs for civil engines are also performed at RR's military engine shops.

It also has a shop at Lachine, Canada which has RB211-22B/-535E4, Tay and BR700/710 capability. RR Deutschland is a BR700/710 shop, while RR Brazil offers capability for the Tay.

RR also has three joint-venture shops: TAESL, Texas; SAESL, Singapore; and HAESL, Hong Kong. TAESL offers the Trent 800, RB211-535E4 and Tay. SAESL offers the Trent 500/700/800 and HAESL offers the RB211 family and Trent 500/700/800. These three shops all offer some hi-tech repairs.

RR also has two joint-venture shops,

IECO, Singapore and TRT, Derby, which specialise in hi-tech component repairs.

Overall, RR has full capability for all RB211 family models, all Trent family models, the Tay 620/650 and BR700/710. This includes 100% capability for all hi-tech component repairs on these engines, which are performed across its network of shops (*see table, page 26*). It also offers maintenance for the V.2500 up to full disassembly and light and general repairs, and has 100% capability for hi-tech repairs on the compressor components it manufactures.

"Hi-tech repairs were either developed by airline shops or licensed specialist component repair providers," explains Ian Lloyd, director of services at RR. "This changed in the 1990s when we built up the overhaul network for the Trent family in Derby, HAESL, SAESL and TAESL. We had to develop hi-tech repairs to support this network. Some repairs are still developed by specialists. In the middle of these two extremes we have a high capability for hi-tech repairs on the RB211-535E4."

Snecma Services has several shops and joint ventures. Its St Quentin shop in France has full routine capability, down to light and general component repairs, for all CFM56 models, and the high pressure and low pressure compressors of the GE90 (*see table, page 26*). This facility is also used to perform some hi-tech repairs for the CFM56.

Its Brussels, Belgium facility has full capability for the CFM56-3, JT8D Basic and JT9D, and includes light and general component repairs and some hi-tech repairs (*see table, page 26*).

Snecma Services has a joint venture with Royal Air Maroc in Casablanca, Morocco, where its shop has just minor module level

*Laser drilling of high pressure turbine blades is one example of hundreds of hi-tech repairs that exist for each engine type. Hi-tech repairs are expensive to develop and original equipment manufacturers limit the number of shops they approve to offer these repairs. Parts repairs have a large influence on lowering total engine maintenance costs, and so it is important to have access to them.*

capability for the CFM56-3/-7.

It also has a joint venture in Chengdu, China with a shop that has full routine capability for the CFM56-3. This includes disassembly to piece-part level and some light repairs.

Snecma Services also has a facility at Chatteraut, France where it repairs four CFM56 minor modules that have been disassembled from major modules from engines at the St Quentin facility.

In addition to its own shops, Snecma Services also has several joint ventures to perform hi-tech repairs. One is with MTU at Chatteraut, France, another is with International Compressor Technologies at Saint-Etienne, France, and a third joint venture with Propulsion Technologies in Miami, Florida. This facility is used to perform high-tech repairs for the CFM56 series, as well as CF6-50, CF6-80, JT8D and V.2500.

"Overall, Snecma Services can offer full maintenance capability on the CFM56, since our major shops perform the basic engine maintenance and routine tasks, while our specialist repair shops perform hi-tech repairs," says Doublet. "The only other shop to have the same level of repair of source-approved repairs for the CFM56 is GEES."

## Independent shops

MTU has three shops in Germany at Hannover, Munich and Berlin. It also has a shop in Vancouver, Canada and one in a joint venture with China Southern Airlines in Zuhai, China.

Its Hannover facility handles the CF6-50C2/-80C2, CFM56-7 and V.2500-A1/A5/D5. Its Munich facility handles the PW2000, and the Berlin shop the CF34 (*see table, page 29*).

The Vancouver shop performs CF6-50C2 and CFM56-3 maintenance, while Zuhai handles the CFM56-3/-5/-7 series.

MTU organises maintenance to disassemble engines down to piece-part level and perform light and general repairs at every shop, and then uses its largest facility at Hannover to perform hi-tech repairs (*see table, page 29*). It also has its joint venture facility with Lufthansa in Malaysia for airfoil repairs.

MTU offers about 90% of possible hi-tech repairs for the CF6-50, about 80% of possible hi-tech repairs for the CF6-80C2 and V.2500 and about 50-

## ORIGINAL EQUIPMENT MANUFACTURER ENGINE SHOP CAPABILITY BREAKDOWN

Engine shop & facility	Engine types	Disassembly to major module	Disassembly to minor module	Disassembly to piece-part level	Light & general parts repair	Hi-tech parts repairs: source-approved or DER FAA approved
<b>GEES</b>						
Strother, Dallas, & Miami USA; Prestwick & Wales, UK; Brazil; China; & Malaysia	CF6-6/-50/-80A/-80C2/-80E, CFM56-2/-3/-5/-7, CF34-3/-8, GE90, PW4000 & RB211	YES	YES	YES	YES	GEES has hundreds of source-approved repairs for its own engine types: CF6, CFM56, CF34 & GE90 families. No source-approved repairs held for PW4000 & RB211
<b>PWES</b>						
Columbus OH	V.2500-A1/A5/D5, JT8D Basic & JT8D-200	YES	YES	YES	YES	PWES uses its extensive network of part repair facilities to perform source-approved & DER FAA-approved parts repairs for its own engines
Cheshire, CT	PW4000-94/-100/-112, PW2000 & JT9D series	YES	YES	YES	YES	
Eagle Services, Singapore	PW4000-94/-100, JT9D-7R4 & CFM56-5C	YES	YES	YES	YES	
Christchurch, NZ	JT8D Standard & JT8D-200	YES	YES	YES	YES	Repairs for JT8D series
Stavanger, Norway	CFM56-3/-5B/-7	YES	YES	YES	YES	For Combustion chambers & fuel nozzles
<b>Rolls-Royce</b>						
Derby & Glasgow, UK	RB211, Trent, Tay & V.2500 families	YES	YES	YES	YES	Rolls-Royce has 100% hi-tech, source-approved parts repair capability for the RB211, Trent, BR700/710 & Tay families.
Lachine, Canada	RB211-535E4, Tay, BR700/710	YES	YES	YES	YES	These are performed across its network of engine shops & other specialist component repair shops. Rolls-Royce also has 100% hi-tech parts repair capability for the compressor section of the V.2500 series.
RR Deutschland	BR700/710	YES	YES	YES	YES	
RR Brazil	Tay	YES	YES	YES	YES	
TAESL	RB211-535E4, Tay, & Trent 800	YES	YES	YES	YES	
SAESL	Trent 500/700/800	YES	YES	YES	YES	
HAESL	RB211 family & Trent 500/700/800	YES	YES	YES	YES	
<b>Snecma Services</b>						
St Quentin, France	CFM56 family	YES	YES	YES	YES	Some hi-tech repairs for the CFM56
	GE90 HPC & LPC	YES	YES	YES	YES	None offered
Brussels, Belgium	CFM56-3, JT8D basic & JT9D	YES	YES	YES	YES	Some hi-tech parts repairs for all engine types
Casablanca, Morocco	CFM56-3/-7	YES	YES			None offered
Chengdu, China	CFM56-3	YES	YES	YES	Some	None offered
						Snecma Services can offer full hi-tech repair capabilities for the CFM56 family across its network of specialist parts repair shops

60% of hi-tech repairs for the PW2000 (see table, page 29). “Our goal is to increase our level of hi-tech repairs to about 90% for each engine type,” says Bodenburg.

Volvo Aero Engine Services (VAES) is a JT9D all series and JT8D-200 shop. Its shop is located at Bromma, Sweden. VAES has capability all the way to light and general repairs for these engines, but it also

offers a few hi-tech repairs for the JT9D series and JT8D-200 (see table, page 29).

Fiat Avio provides services for the JT8D-200 series and CFM56-3/-5B/-7 (see table, page 29). It capability extends



all the way to light and general repairs. Fiat Avio has source-approved repairs for the JT8D-200 and is due to get source-approved repair capability on the CFM56-3's low pressure turbine module components by the first quarter of 2004. Examples of repairs for the JT8D-200 are fuel nozzle modification and high pressure compressor stator vane replacement.

Turbine Motor Works in Manston, United Kingdom offers services for the JT3D series and CF6-50 (see table, page 29). It can offer the first level of engine maintenance for these, although it cannot provide testing for the CF6-50. It also offers module disassembly into minor modules and then piece-part components and light repairs for them, although this capability will not be complete for the CF6-50 until the end of 2003. It also offers light and general repairs for the two engines. It does not offer hi-tech repairs.

Aerotruth in Miami, Florida is a major JT8D facility, offering services for both series. This includes disassembly to piece-part level for both series (see table, page 29). Aerotruth can also repair 65-70% of piece-part components of the two engine families, and sub-contracts the rest (turbine blades, vanes and stators and major casing repairs). The repairs Aerotruth offers include machining, grinding, plasma soft and hard coating, NiCad plating, welding, full cleaning and non-destructive testing type component repairs. It also offers all general repairs for the two series. The hi-tech repair it offers for the two families is NiCad coating on all rotating parts. "This is the only major hi-tech repair on the JT8D, and has only been in existence for about two years," explains Jose Leon, senior

vice president of marketing at Aerotruth. "Early production engines had all repairs in the engine shop manual. In the past all JT8D shops were permitted to perform all repairs in the manual, and source-approved or DER FAA repairs were not required."

Aviation Engine Service is another shop in Miami, Florida and offers services for the JT3D, JT8D Basic and JT8D-200 series. Its capabilities go all the way to light and general repairs for all three engine types (see table, page 29), but it does not offer hi-tech repairs.

Newjet is another engine shop based in Miami, Florida catering for the JT8D Basic and JT8D-200 families. The shop has full capability up to light and general repair level (see table, page 29). It does not offer hi-tech repairs, although few exist outside of the engine repair manual.

GAMCO, located at Abu Dhabi, United Arab Emirates offers services for the CF6-80C2, CFM56-5A/-5C and RB211-22B/-524 (see table, page 29).

It offers disassembly of major modules for all these types, as well as the Trent 700. It only disassembles the CFM56-5C into minor modules, but disassembles minor modules into piece-part level and performs light repairs for the CF6-80C2 and CFM56-5A. It offers light and general component repairs for the CF6-80C2, CFM56-5A/-5C, just light parts repairs for the Trent 700, and general repairs for the RB211-22B/-524.

Jordan Airmotive based in Amman, Jordan offers services for the JT3D, JT8D Basic, RB211-524 and CF6-80C2. It has a 100,000lbs test cell and disassembles all types except the CFM56 into major modules (see table, page 29). It further disassembles major modules down to piece-part level for the JT3D, JT8D and

*Development of hi-tech repairs can take months or years, and several years or even decades for a shop to build its hi-tech repair capability to a high level for a single engine type.*

RB211-524. It does not carry out component repairs, but is in the final process of acquiring source-approved repairs for the JT3D and JT8D.

Ameco Beijing is a major independent facility in China. It offers services for the CFM56-3B, JT9D-7R4, PW4000-94 and RB211-535E4 (see table, page 29).

Its capabilities for each engine are varied. It offers major module disassembly and light repairs for the CFM56-3, but not minor module disassembly, general or source-approved repairs (see table, page 29). Its main engine types are the JT9D-7R4 and PW4000-94. It has full capability up to light and general repairs for these engines, as well as about 21 source approved repairs (see table, page 29) for each type.

It also offers QEC build up for the CFM56-5C4/-7 and PW4000-112.

IHI is a partner of International Aero Engines and is a full capability engine shop based in Chiyoda-ku, Japan. It currently offers services for the V.2500-A1/A5/D5, CFM56-3 and CF34-3 series. It offers capability all the way up to light and general repairs for these engines (see table, page 29). It offers about 60% source-approved repairs for the V.2500 series, about 30% for the CFM56-3 and 10% for the CF34-3 (see table, page 29). It does not, however, have HPT blade and vane repair, because this is offered by PW.

IHI also plans to have CFM56-7 capability.

## Airline shops

Lufthansa Technik is one of the largest airline engine shops in Europe. Besides its main Hamburg facility it has a shop at Dublin (Lufthansa Airmotive). It also has many other subsidiaries, including Lufthansa Technik Tulsa, Lufthansa Technik Shannon Turbine, Lufthansa Technik Philippines, Lufthansa Aero (Alzey, Germany). Its joint ventures include Ameco Beijing in Beijing, China with Air China.

Its main engine shops are Hamburg and Dublin, and its Shannon facility is used for hi-tech parts repairs.

Hamburg handles all CFM56 models, except the -2, which is handled by Lufthansa Airmotive.

Hamburg handles the JT9D, PW4000-94, CF6-50/-80C2 and V.2500-A5/D5 (see table, page 30).

Lufthansa Airmotive offers services

## INDEPENDENT ENGINE MAINTENANCE PROVIDERS ENGINE SHOP CAPABILITY BREAKDOWN

Engine shop & facility	Engine types	Disassembly to major module	Disassembly to minor module	Disassembly to piece-part level	Light & general parts repair	Hi-tech parts repairs: source-approved or DER FAA approved
<b>MTU</b>						
Hannover, Germany	CF6-50C2/-80C2,	YES	YES	YES	YES	All hi-tech parts repairs sent to Hannover shop from all other shops. Has 90% of hi-tech repairs for CF6-50, 80% for the CF6-80C2 & V.2500, and 50-60% of hi-tech repairs for the PW200
	CFM56-7 & V.2500	YES	YES	YES	YES	
Munich, Germany	PW2000	YES	YES	YES	YES	
Berlin, Germany	CF34	YES	YES	YES	YES	
Vancouver, Canada	CF6-50C2 & CFM56-3	YES	YES	YES	YES	
Zuhai, China	CFM56-3/-5/-7					
<b>VAES</b>						
Bromma, Sweden	JT9D series & JT8D-200	YES	YES	YES	YES	Some hi-tech repairs for both engine types
<b>FIAT AVIO</b>						
Turin, Italy	JT8D-200 & CFM56-3/-5B/-7	YES	YES	YES	YES	Some hi-tech parts repairs for the JT8D-200. A few hi-tech repairs for CFM56-3 LPT module due in 1st quarter 2004
<b>Turbine Motor Works</b>						
Manston, UK	JT3D & CF6-50	YES	YES	YES	YES	None offered
<b>Aerothrust</b>						
Miami, USA	JT8D Basic & JT8D-200	YES	YES	YES	YES	Repairs for 65-70% of piece part components.
<b>Aviation Engine Service</b>						
Miami, USA	JT3D, JT8D Basic & JT8D-200	YES	YES	YES	YES	None offered
<b>Newjet</b>						
Miami, USA	JT8D Basic & JT8D-200	YES	YES	YES	YES	None offered
<b>GAMCO</b>						
Abu Dhabi, UAE	CF6-80C2	YES	NO	YES	YES	None offered
	CFM56-5A	YES	NO	YES	YES	None offered
	CFM56-5C	YES	YES	YES	YES	None offered
	RB211-22B/-524	YES	NO	NO	YES	None offered
	Trent 700	YES	NO	NO	YES	None offered
<b>Jordan Airmotive</b>						
Amman, Jordan	JT3D, JT8D Basic,	YES	YES	YES	NO	Final process of acquiring source-approved repairs for JT3D & JT8D
	RB211-524 & CF6-80C2	YES	YES	YES	NO	
<b>Ameco Beijing</b>						
Beijing, China	CFM56-3	YES	NO	NO	YES	None offered
	JT9D-7R4 & PW4000-94	YES	YES	YES	YES	21 Source-approved for each
	RB211-535E4	YES	YES	YES	YES	None offered
<b>IHI</b>						
Chiyoda-ku, Japan	V.2500 series & CFM56-3	YES	YES	YES	YES	60% for V.2500 & 30% for CFM56-3

## AIRLINE ENGINE MAINTENANCE PROVIDERS ENGINE SHOP CAPABILITY BREAKDOWN

Engine shop & facility	Engine types	Disassembly to major module	Disassembly to minor module	Disassembly to piece-part level	Light & general parts repair	Hi-tech parts repairs: source-approved or DER FAA approved
<b>Lufthansa Technik</b>						
Hamburg, Germany	CFM56-3/-5/-7 series, JT9D, PW4000,	YES	YES	YES	YES	All hi-tech parts repairs from all shops sent to Hamburg. Lufthansa Technik has 90% of hi-tech repairs for all engine types it has services for
	CF6-50/-80C2 & V.2500	YES	YES	YES	YES	
Dublin, Ireland	CFM56-2, JT8D & JT9D	YES	YES	YES	YES	
<b>Air France Industries</b>						
Paris, France	CF6-50C2/-80C2 & CFM56-3/-5 series	YES	YES	YES	YES	Some hi-tech repairs for the CF6-50C2/80C2
<b>SR Technics</b>						
Zurich, Switzerland	CFM56-5B/C/-7, JT8D-200 & PW4000	YES	YES	YES	YES	Some hi-tech repairs offered for all four types
<b>KLM Engineering</b>						
Amsterdam, Netherlands	CF6-50/-80A/-80C2	YES	YES	YES	YES	Offers several hundred source-approved repairs
<b>Air Portugal</b>						
Lisbon, Portugal	JT3D, JT8D basic, RB211-524B4, CFM56-3/5A/B/C/-7 & CF6-80C2	YES	YES	YES	YES	Some source-approved repairs for all engine types
<b>Alitalia</b>						
Rome, Italy	CF6-50C2/-80C2	YES	YES	YES	YES	None offered
<b>Iberia</b>						
Madrid, Spain	CFM56-5A/B/5C, JT8D-200, JT9D & RB211-535E4	YES	YES	YES	YES	Some source-approved repairs for all engine types
<b>Finnair</b>						
Helsinki, Finland	CF6-50C2/-80C2	YES	YES	YES	YES	None offered
	JT8D-200	YES	YES	YES	YES	5% source-approved
	PW2000	YES				None offered
	CFM56-5B	YES	YES	YES	YES	None offered
<b>United Service</b>						
San Francisco, USA	PW4000-94/-112, PW2000 & CFM56-3	YES	YES	YES	YES	Source-approved repairs offered for all engine types
<b>Delta TechOps</b>						
Atlanta, GA	JT8D-200, CFM56-3/-7, PW2000, PW4000-94 & CF6-80A	YES	YES	YES	YES	Some source-approved repairs for the JT8D-200 & PW2000

for the CFM56-2/-3/-7, JT9D-7A/7F/7J/7Q/59A and JT8D Standard. It has full capability for all these engines up to light and general repairs (*see table, this page*). It has a few source-approved

repairs for the CFM56, although most hi-tech repairs are sent to Hamburg. Lufthansa Airmotive has several DER FAA hi-tech parts repairs.

These major shops provide capability

down to the general and light component repair level. Hi-tech repairs are then performed at Hamburg, and Lufthansa Technik offers more than 90% of hi-tech repairs for all engine types (*see table,*

## AIRLINE ENGINE MAINTENANCE PROVIDERS ENGINE SHOP CAPABILITY BREAKDOWN

Engine shop & facility	Engine types	Disassembly to major module	Disassembly to minor module	Disassembly to piece-part level	Light & general parts repair	Hi-tech parts repairs: source-approved or DER FAA approved
<b>South African Airways</b>						
Johannesburg, South Africa	JT8D Basic, JT9D-7R4,	YES	YES	YES	YES	About 60% of source-approved repairs
	RB211-524H	Test only				
<b>Qantas</b>						
Sydney, Australia	RB211-524D4/G/H,	YES	YES	YES	YES	Some source-approved repairs offered for all types
	CF6-80C2 & CFM56-3B/C					
<b>ANZES</b>						
Christchurch, New Zealand	RB211-524 & CF6-80	YES	YES	YES	YES	None offered

page 30). Its Philippines facility is also used for parts repairs.

Air France Industries is another major engine shop. Its main engine shop is at Orly, Paris, France and provides services for the CF6-50C2/-80C2 and CFM56-3/-5A/B/C (see table, page 30). From 2004 it will also offer the GE90.

Air France Industries provides maintenance up to disassembly to piece-part level and general parts repairs for all these engine types, but does not offer light repairs (see table, page 30). Air France Industries also provides hi-tech repairs for the CF6-50C2/-80C2.

SR Technics offers maintenance for the CFM56-5B/C/-7, JT8D-200 and PW4000-94/-100 (see table, page 30). SR Technics has full overhaul capability for these engines, and thus offers services up to light and general repairs for parts and components. It also offers some source-approved repairs for all these engine types.

KLM Engineering & Maintenance is a specialist maintenance provider for the CF6 series, with capability for the -50/-80A/-80C2 series. It is also initiating its CFM56-7 capability.

Its capability on the CF6 family goes all the way to light component repair capability (see table, page 30), and offers several types of general repairs, including plasma application, laser cladding and immersion inspections.

It offers several hundred source-approved repairs for the CF6 family, and is listed in the CF6 engine shop manual as a source-approved repair provider. Examples are Molybdag coatings on fan blades to prevent chafing. KLM Engineering & Maintenance also plans to develop source-approved repairs for the CFM56-7.

Air Portugal offers engine maintenance services for an extensive number of engine types, including the

JT8D Basic, JT3D, RB211-524B4, CFM56-3/5A/5B/5C/-7 and CF6-80C2 (see table, page 30). It has capability up to light component repair for all these types.

It also offers general parts repair capability for the JT8D, JT3D, RB211 and CFM56, and source-approved repairs each for the JT8D, JT3D, RB211-524 and CFM56-3 (see table, page 30). Examples are combustion chamber plasma spray, NiCad plating, and shaft and spool shot peening.

Alitalia has services for the CF6-50C2/-80C2, and has capability up to light part repairs (see table, page 30). It does not offer general repairs or source-approved repairs.

Iberia's powerplant shop offers maintenance for a variety of engine types, including the CFM56-5A/B/-5C, JT8D-200, JT9D-7Q/-59A/-70 and RB211-535E4 (see table, page 30). Its capability extends to general and light part repairs for all these types. It further offers source-approved repairs for the CFM56, JT8D-200, JT9D and RB211. Examples are fan disk shot peening and vane replacement on stators on the PW engines.

Finnair provides maintenance for the CF6-50C2/-80C2, JT8D-200, PW2000 and CFM56-5B (see table, page 30). Finnair only has the capability to split the PW2000 into major modules (see table, page 30). It then has the capability to disassemble the CFM56-5B to piece-part level and perform light repairs. It can further perform all levels of maintenance up to light and general repairs for the CF6-50C2/-80C2 and JT8D-200, and offers about 5% of source-approved repairs for the JT8D-200.

Few airlines in North America offer third-party maintenance services to other airlines. The two exceptions in the US are United and Delta.

United Services offers engine maintenance for the PW4000-94/-112,

PW2000 and CFM56-3 (see table, page 30). Being a large carrier and having a large engine shop, United Services has full capability for these engine types right up to source-approved repairs for all four engine variants. Examples of these hi-tech repairs are fan blade peening, knife-edge seal coating, peening of blade slots, blade tip grind repair, seal teeth weld repair, plasma coating of HPT blade retaining plates and brush seal modification of HPT cooling duct.

Delta TechOps offers services for engine types in its own airline fleet. These are the JT8D-200, CFM56-3/-7, PW2000, PW4000-94 and CF6-80A. Its capabilities go all the way to light and general repair for all these types, and it also has some source approved repairs for the PW2000, and a few for the JT8D-200 (see table, page 30).

South African Airways offers services for the JT8D Basic, JT9D-7F/-7R4 and RB211-524H. It only, however, has test cell capability for the RB211, but offers full overhaul for the JT8D and JT9D (see table, this page). This goes all the way to disassembly to piece-part level and light and general repairs. It also has about 60% of source approved repairs for both engine types.

Qantas has capability for the RB211-524D4/G2/H, CF6-80C2 and CFM56-3B/3C. It has full capability for all these types including source-approved repairs (see table, this page), although it is unable to determine what percentage of available source-approved repairs it offers.

Air New Zealand Engineering Services (ANZES) has its own engine shop in addition to the joint venture with PW. ANZES offers services for the RB211-254 series and CF6-80 series. It provides full capability up to light and general component repair level, but does not offer source-approved repairs (see table, this page). **AC**