Engine shop visits and overhauls have been sub-contracted by airlines for many years. There are many other facets of engine maintenance & management for airlines to consider. The process of sub-contracting these to third party providers is examined.

Sub-contracting engine operational support

The outsourcing of engine shop-visit maintenance was established long ago, but all other aspects of engine maintenance and management have been kept in-house by airlines. More operators are looking to sub-contract more engine-related activities, but how can this be achieved while maintaining a reliable fleet operation?

Elements of maintenance

There are numerous tasks encompassed by the maintenance and management of engines. Besides shop visits, there are several other elements airlines have to organise and manage. These include: line maintenance, line replaceable unit (LRU) and accessory rotable component maintenance and management; on-call assistance; aircraft-on-ground (AOG) assistance; engine changes; health monitoring; and maintenance planning and engine management.

Although aviation authorities require airlines to have technical directors to track and keep engine health monitoring data and maintenance records, it is possible for airlines to sub-contract all the related activities to several or even one specialist provider.

Line maintenance

Line and light checks on aircraft include daily, pre-flight, transit and weekly checks. Pre-flight and transit checks are mainly confined to visual and simple inspections, and more airlines are leaving these to flightcrew. These types of check may also require some non-routine rectifications due to problems such as malfunctioning systems. Rectifying these often requires mechanics and replacement parts, and may require some specialist equipment. Rectification will only occur for these checks if the technical problems encountered are ones which cannot be deferred until daily, weekly or heavier checks.

The daily and weekly checks have larger workscopes and these are performed by mechanics. These tasks include the downloading of engine health data from the aircraft's flight management computers.

Daily and weekly checks are more likely to have defects that need to be cleared in addition to the routine tasks. Routine tasks in line and light checks are treated as one group, rather than distinguishing between those relating to the airframe and those relating to engines. The rectification of defects, however, may include specialist engine-related tasks.

Examples of problems that arise during operation of engines are the detection of vibrations that indicate an engine's turbomachinery may be at fault, or in-flight shutdowns. The aircraft may also have system problems. These are analysed with troubleshooting techniques during line checks, and may ultimately reveal that engine accessory components or LRUs are at fault and so need to be changed.

On-call assistance & AOG

Problems that arise with engines on the line can be divided between those that can be dealt with by line mechanics and on the line, and those that require a heavier workscope and longer downtimes. Examples of problems that cause longer downtimes and require larger fixes are foreign object damage (FOD) to engines, other types of physical damage and engine changes.

Airlines have traditionally performed all their own line maintenance at their home bases and other hubs where they have significant operations. Airlines generally do less line maintenance at outstations on their route networks where they have limited operations. For problems that require component changes, the clearing of defects, investigation or emergencies such as engine changes, operators have arrangements with local airlines at hubs with significant line maintenance capability. In the event of these situations occurring at outstations where there is limited line maintenance infrastructure airlines are forced to either send their own teams of mechanics and related equipment, or source on-call and AOG assistance from other carriers.

Besides these various non-routine situations, airlines also have to arrange some engine-related line maintenance tasks. The first of these are borescope inspections on various engine modules at differing intervals. These are scheduled to coincide with A or C checks, when there is sufficient downtime to open the engine cowling. These inspections can lead to findings such as damaged blades, which require either some light engine repairs being performed on-wing, or require an engine removal and change within a certain limit. Some findings may also lead to light repairs being made, for example to the top case compressor.

Sub-contracting

Many airlines find it economic to perform their own line maintenance, at least at their main base of operation, when their fleet size has grown to more than about 15 aircraft. All airlines still nevertheless have to make arrangements for non-routine line maintenance, on-call assistance and AOG situations across the whole of their networks.

More airlines are also sub-contracting their entire line maintenance operations to third-party providers. An extreme example is Virgin America, based at San Francisco, which has sub-contracted its

Line maintenance and operational support is one element of engine maintenance & management that airlines have traditionally performed themselves and are able to sub-contract to third party providers.

entire line maintenance operation to Lufthansa Technik.

Airlines ultimately need to have maintenance providers close at hand to perform the various line maintenance and AOG tasks described, with the minimum impact on their operation. Some tasks, such as engine changes, require large and heavy equipment, like engine slings, and teams of mechanics, as well as downtime of at least 36 hours and up to 72 hours. Such events not only require mechanics and equipment, but also arrangements for spare engines, the transport of spare engines, arrangements for delayed passengers, and the sourcing of stand-in aircraft to operate the planned schedule. AOG events are therefore costly.

The impact of AOGs and engine changes is minimal if problems occur at busy airports where there are plentiful line maintenance providers. Airlines rarely have problems sourcing sufficient line maintenance capability on short-haul networks, but certain outstations on long-haul networks can cause more problems. "Over the combined networks of Air France and KLM we have line maintenance activity at about 300 different airports," says Christian Tallec, vice president of marketing and sales at Air France Industries. "Most of these are in Europe, but they also include some of the cities we fly to across our long-haul networks. One example of a distant outstation is Ho Chi Minh City in Vietnam. We only usually provide line maintenance as part of a total maintenance package, however.

"We can offer engine LRU changes and troubleshooting for a large number of aircraft and engine combinations. This includes the A320 family, the A310, A330, A340, 737 family, 767, 777 and 747-400. The accompanying engine types are the CFM56-3/-5B/-5C/-7, CF6-50/-80C2, CF6-80E1, GE90, and PW4000-112," continues Tallec. "We also offer specialist tasks and this includes borescoping, top case repairs, fuel nozzle changes and specialised troubleshooting. We can send mechanics to perform these on-the-spot tasks. We can also provide ad-hoc assistance which is paid for on a time-and-material basis."

Other European providers of line maintenance include the European Maintenance Services (EMS) group of partners. These comprise Europe Aviation based in Paris Orly, Stella Aviation based in Amsterdam, and Louro Aviation based in Lisbon. EMS also has line maintenance stations at Liege in Belgium, where it has up to 15 mechanics for larger line maintenance tasks. Overall EMS has capability at about 40 European airports, as well as some in Brazil, the Caribbean, Caracas and North Africa. It will also shortly be adding Abu Dhabi. EMS can offer services for all 737 models and the CFM56-3/-7; the 747-400 with PW4000, CF6-80C2 and JT9D-7R4; the 757 with PW2000 and RB211-535; the 767 with PW4000, CF6-80C2 and JT9D; the A320 family with the CFM56-5 and V2500; the A330 with all engine types; and the A340.

"EMS's partners offer all types of line maintenance activity, and we can add capability for additional aircraft and engine types if there is sufficient demand from our customers," explains Johan Meganck, commercial director at EMS.

Lufthansa Technik also provides an extensive line maintenance offering for all major Airbus types, except the A380; all major Boeing types; the CRJ-100/-200/-700; and the MD-11. The engine types it has service for are all major General Electric (GE) types, all major Pratt & Whitney (PW) types; the RB211-535; Trent 700; and Trent 800. "We have 68 major line stations globally and can add services for start-up airlines which want us to add new stations if required," says Thomas Boettger, director of customer services engines at Lufthansa Technik. "One example is the line maintenance services we provide to Virgin America at its base in San Francisco. We do virtually everything for Virgin America's 14 A320s. This includes: providing line mechanics; provisioning of rotables and logistics; providing equipment and tooling; arranging materials and consumables; and providing all levels of engineering."

United Services has extensive capabilities for its own fleet, which includes the A320 family and V2500, 737-300 and CFM56-3, 757 and PW2000, 767 and PW4056, 747-400 and PW4056, and 777 with PW4000-112. In addition to United's own aircraft and engine types it can provide engine-related line maintenance for the CF6-80C2 and RB211-524 on the 747-400 and the GE90 on the 777. It also has capability for the A340 and CFM56-5C, and A330 with the three engine choices.

"We have five major hubs in the US that include Washington Dulles, Chicago O'Hare, Denver, San Francisco, and Los Angeles. We also serve Mexico City," says Jerry Bemis, managing director of line maintenance at United Services. "While we operate to a large number of cities within the US on our domestic network, we also have an extensive long-haul network where we operate the 777 and 747-400. This includes operations to Tokyo Narita, Bangkok, Taipei, Sydney and Sao Paulo. We also have an extensive line maintenance base at London Heathrow. These are large line maintenance stations where we have up to 50 line mechanics. Overall, we have about 200 line mechanics at these long-haul stations."

On-call assistance

The locations of line maintenance stations operated by these various providers and others mean that there are services available for airlines in most locations when required. Lighter line

While there have been specialist independent providers of heavy airframe and engine shop visit maintenance for many years, there is now an increasing number of specialist providers of line maintenance and operational support.

maintenance activities are relatively easy to arrange for most carriers for the majority of aircraft and engine types. Heavier and less frequent line maintenance activities, such as on-call assistance for FOD incidents, light engine repairs and engine changes, require more specialist services.

While airline technical departments and independent maintenance providers offer lighter line maintenance, original equipment manufacturers (OEMs) provide more specialist services. "GE Aviation has five on-wing support centres for heavier line maintenance and small on-wing repair type services for engines. These are at Cincinnati, Dallas-Fort Worth, Incheon Seoul, Xiamen in China, and London's Heathrow and Stansted airports," says Abbey Posner, general manager on-wing support for GE Aviation. "From these on-wing support centres we provide borescope inspections, as well as engine changes, light repairs such as top and bottom case repairs, and warranty work. We can provide LRU and engine accessory and quick engine change (QEC) kit changes at these shops. We also hold stocks of LRUs and accessories at these locations and also have the material to feed an engine change. These are in-hand with the short-term and long-term spare engine provisioning services offered by GE Engine Leasing (GEEL) and Shannon Engine Support (SES). Not only do we support all GE and CFM International types, but we also provide on-call assistance and engine changes for several competitor engines."

On-call assistance and AOG services require a quick reaction time to assist customers and minimise the financial impact of these situations. "In many AOG scenarios it takes some time to react and travel to where the affected aircraft is," says Posner. "It therefore helps to be close, and the location of our five shops provides us with broad coverage. Depending on the nature of the technical problem we may have to transport engine change equipment and tooling, blend damaged engine blades on-wing, replace accessory components, adjust fuel nozzles, or repair certain accessories."

The number of line stations that a provider has, and their location, determine their ability to assist customers. "We can react fast, but are sometimes hampered by the requirement to have visas for our mechanics, for example," explains Bemis.

Different providers have different outstations, and Lufthansa Technik has team stations located at: Tulsa, Oklahoma; Buenos Aires, Argentina; Johannesburg, South Africa; Mumbai, India; and Hong Kong. "Our station in Johannesburg, for example, can be justified because there are a lot of FOD incidents and we have provided several top case repairs for Comair. Being on-site means that we can react quicker," says Boettger. "We have a global reach and can provide on-call assistance in every continent, except Australia because of the distance. We have set up our capability to provide assistance at remote airports in many parts of the world."

Engine changes

Non-routine engine changes are the heaviest task an airline has to make arrangements for. Except when they conveniently occur at a home base, non-routine engine changes require the co-ordination of providing a replacement engine, a QEC kit and all accessories, the necessary tooling and equipment, and mechanics with the appropriate skills and approvals. The tooling and equipment is heavy and large, since it includes slings to remove and install engines on the aircraft, and cradles to carry separated engines. Often some or all of this equipment can be brought in from a relatively close location if the provider has to travel a large distance to reach the affected aircraft.

A lot of the logistics and planning revolve around engine availability, and whether it is bare or supplied with a QEC. "A serious situation effectively means the aircraft is hospitalised, for example when the engine experiences heavy FOD damage, has a gearbox failure or suffers a serious loss of oil pressure," explains Posner. "The situation is stressful for the airline, since it means that aircraft can be stuck at outstations a long way from home for a long time. A replacement engine, QEC, tooling and equipment, and mechanics all have to be supplied. The co-ordination of all this means that airlines need to have arrangements in place for when these events occur."

Once a maintenance provider is informed of a need for an engine change and arrangements have been made, equipment and the engine have to be packaged and transported. "Most engines are too large to fit into the cargo hold of a passenger aircraft," explains Bemis. "The maintenance provider should have logistics in place to get the engine to the aircraft whether it is by truck or freight aircraft. It also means that equipment may have to pass through customs, which causes delays in the whole process."

The process still requires a lot of coordination and arranging. "We can perform engine changes for all the types we support, and can do these in many locations around the world," says Tallec. "For example we co-ordinated an engine change for a 777 in Irkutsk in Siberia, which required the shipping of an engine in an Antonov freighter."

Other major line maintenance providers offer extensive capability for engine changes. "We have the tooling to do engine changes on all the aircraft and engine types we offer line maintenance

One element of engine management and operational support for airlines to arrange is the provisioning, repair and management of engine accessory and rotable components. More of these activities are being sourced by airlines from specialist providers.

services for," says Meganck. "Being able to perform an engine change depends on the location of the aircraft, but we can use another company's equipment if it means speeding up the process. Our complete line maintenance contracts include arranging the logistics of engine changes for customers when they are required. This includes shipping the engine, other material, and tooling. We are also able to access spare engines and QEC kits for our customers if they are needed."

Engine LRU provisioning

Another element of engine-related maintenance is the provisioning, repair and management of LRUs and accessories. These items include: gearboxes; starter motor and ignition systems; cooling and lubricating oil systems and reservoir; airbleed system; fuel system and controls; variable stator controls; ice and fire protection systems; and reverser system and controls.

These items form the QEC kit and are all maintained on an on-condition basis. They therefore fail at random, and problems are either detected by fault messages being displayed on the flightdeck or via troubleshooting during line checks. Failures or problems with specific rotables will require their removal and replacement. Removed parts will then have to be tested, repaired, certified and provided with the appropriate documentation, before they are re-supplied to the rotables inventory. This all requires management, logistics, the appropriate facilities and capabilities, and investment.

Engine LRUs can either be considered separately from the remaining airframe LRUs, or all rotables can be considered in a single package. There are also several ways airlines can arrange the process of supplying, repairing and managing LRUs and rotables.

It is becoming more common for airlines to seek complete packages. Under these systems providers lease airlines a home-base stock of rotables with high failure rates or ones that have the highest impact on operating schedule reliability. Other items are made available through a pooling arrangement, and so are held by the provider and transported to the airlines when required. This second element is provided on a fixed rate per FH basis. The repair, logistics and management of all parts are arranged and managed by the provider, and can then be paid for by the airline on a fixed rate per FH basis.

Finnair Technical Services, for example, provides total LRU packages for engines. "These can be offered to the airline on a standalone basis, or together with engine maintenance," explains Tuomo Karhumaki, vice president of the powerplant department at Finnair Technical Services. "We provide these LRU services for the CFM56-5B, CF6-80C2, JT8D-200 series and the PW100. We will probably add the CF34-8C and -10 in the future."

Airlines' requirements for LRUs and rotables differ. "Some airlines want contracts for the repair and overhaul of the engine and LRUs, together with a supply of serviceable LRUs. Other carriers want just a component contract," explains Boettger. "Some LRUs get repaired while the engine is in the shop, so it makes sense to combine engine maintenance LRU contracts together as a package."

Engineering & management

In addition to the on-hand maintenance activities, airlines also require extensive engineering and management services for their engines. These activities include following and analysing health monitoring data, removal planning for shop visits, shop visit workscope definition, life limited part (LLP) planning, monitoring airworthiness directives (ADs) and service bulletins (SBs), overall maintenance management, and keeping maintenance records.

These services are specialised, and are offered by a limited number of suppliers. "We have health monitoring and data analysis for the Air France and KLM fleets, and do provide engine maintenance planning and management as part of an engineering support package for our customers. Within this we advise our customers how they get the lowest cost per engine flight hour," says Tallec.

Lufthansa Technik can offer a complete engine management service, as well as providing spare engines on a short- and medium-term basis. "We have 180 spare engines of various types, and can provide coverage for up to two years," says Boettger. "We also have total engine maintenance and engineering support contracts for some customers that last 10 years, and under these airlines can completely rely on us for spare engine provisioning."

Total Engine Support (TES) in the UK is unique in that it not only provides all required engineering and management services for engines, it also advises airlines on a financial and commercial basis. "Our EFPAC software product is used to analyse health monitoring data, track engine utilisation on a flight hour and flight cycle basis, monitor ADs and SBs, track LLP lives, plan removals, devise shop visit workscopes, estimate the cost of shop visits, calculate LLP reserves, and provide estimates of full engine reserves. The unique part of EFPAC is its financial and commercial capability to predict complete engine maintenance costs," explains Paul Smith, programme manager at TES. "EFPAC's capability means we can also negotiate repair contracts and engine lease contracts for airlines." AC