Time for a health check — engine condition monitoring

In recent years, engine operating costs and reliability have seen significant improvements thanks, in major part, to enhanced data gathering, analysis and trending. The new breed of more data-capable aircraft such as the 787 and A380 will offer developed engine trending capabilities and we will see some integration with emerging aircraft health monitoring (AHM) and electronic technical log (ETL) systems, thus facilitating the development of airlines operations control rooms with real time asset management of the airframe and engine. *Aircraft Technology* reports.

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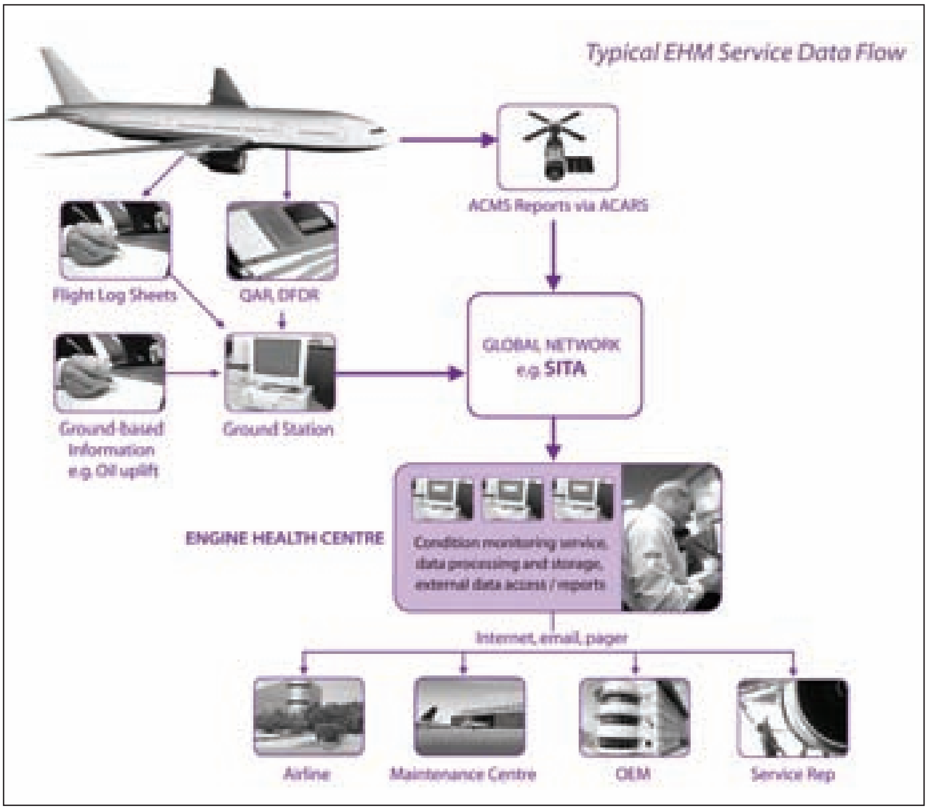
Sophisticated engine health monitoring (EHM) systems, sometimes known as engine condition trend monitoring (ECTM), are offered by each OEM as a software tool to facilitate analysis by the airlines' own propulsion engineers. Increasingly these tools can also be provided by MRO organisations as part of defined support packages or by specialist service providers using classic 'pay-by-the-hour' EHM using an Application Service Provider (ASP) model. Such services benefit from extensive accumulated fleetwide knowledge on the specific engine model allied with strong engineering domain expertise and resilient 24/7 service coverage, where required. Service level flexibility is a key factor in managing different types of operators with their respective needs. A corporate jet operator flying 300-500 hours per annum may only download data from a Quick Access Recorder (QAR) every month for analysis, whereas Ultra Long Range operations by A340-500 operators will need 'real time' decision support.

Early EHM systems had heavy dependency on manual labour utilising desk top equipment with frequently subjectivity of diagnoses. For the user this often meant unbearable peak workloads and the systems were relatively expensive and not easily scaleable. Typical modern EHM systems offer 24/7 services through resilient server farms with consistent, 'learnt' diagnoses and manual labour providing only a supervisory overview. Computational intelligence (CI) tools allow the models to be progressively enhanced through feedback from growing fleet experience while the visualisation of the data has been greatly enhanced by the availability of latest web-based systems.

An EHM service provider such as Data Systems & Solutions (DS&S) can typically process over 10,000 reports a day from the supported fleet of around 7,000 engines with 300 operators. These range from single aircraft corporate users to monitored fleets of around 300 aircraft with regional and major airlines. Of these



around 50 per cent are monitored on a 24/7 basis with reports being made available via the web typically in around 10 minutes against a service level agreement of three hours.

Increasingly, airlines buying new aircraft are encouraged to take OEM support package menus which generally have integral OEM-provided EHM services built-in. The legacy airlines often prefer to perform the engine trend analysis themselves using tools provided by the engine manufacturer such as COMPASS offered by DS&S for Rolls-Royce and IAE engines, SAGE by GE for the CFM56 and GE engines or Pratt & Whitney's TEAM for the V2500 and PW engines.

An effective engine health monitoring (EHM) service must answer four key questions in order to deliver effective results to its customer: Who do you tell about it? When do you tell them about it? How do you tell them about it? What can they do about it?

Saving time, saving money

Clearly EHM services must add value and flexibility to improve airline operations by providing the important information *when* it is needed and *where* it is needed. To succeed a service must also provide easy access to background data, providing expert diagnosis of trends through the use of experienced gas turbine engineers, supported by sophisticated trending tools and models. Competitive pricing is critical to offer a return on investment, which typically will well exceed 400 per cent. The key benefit of a service is the improvement of cashflow stability through the elimination of fixed costs which would have reduced profitability during seasonal lows or market downturns. These services must also be provided while fully meeting the requirements of EASA Ops 1 or FAR Part 121 regulations, as appropriate.

An effective engine health monitoring (EHM) service must answer four key questions in order to deliver effective results to its customer: Who do you tell about the problem? When do you tell them about it? How do you tell them about it? What can they do about it? Clearly such services must allow the airline to concentrate on 'management by exception' focusing on significant anomalous trends while confidently ignoring other changed (but normal) behaviour. Such decision support services must deliver accurate, rapid, relevant and concise information with the ability to transform data into actionable information and future knowledge.

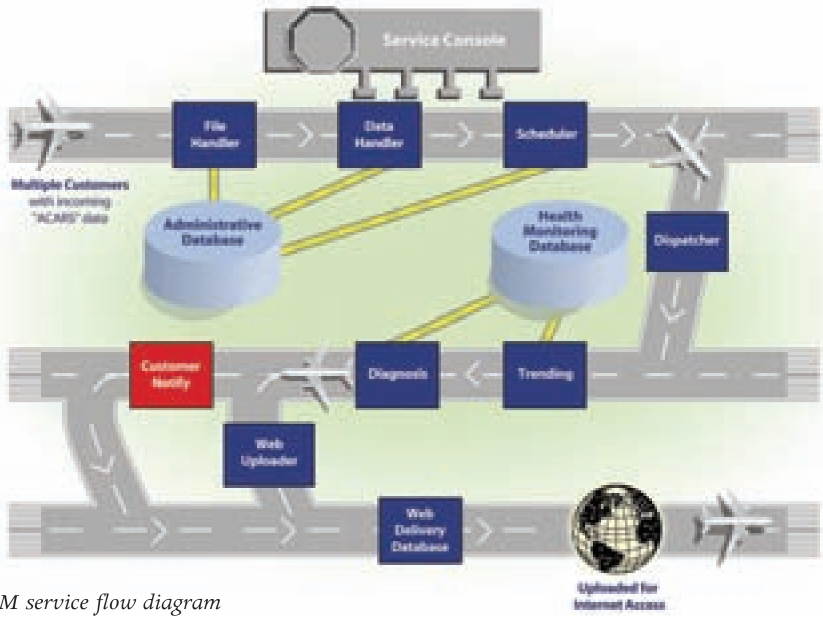
An EHM service should let the appropriate engineers know when something has been detected. The creation of a series of service 'user profiles', helps ensure that the user has the skills, opportunity and equipment to do something about the problem. The speed with which they need to be informed is dictated by the perceived severity of the potential problem and the typical time to failure (TTF). If the average TTF of a diagnosed problem is a small number of cycles, then speed is obviously very important. The method of notification may include mobile phone SMS messages; display on a website or even auto- generation of faxed or e-mail notification. To facilitate rapid rectification thus further reducing costs, an appropriate level of instructional information should be included in the alert message, ideally linking to maintenance / inspection process manuals.

The capability of modern web-based EHM systems allows new engine models to be added into an EHM service provider's portfolio, relatively rapidly. Although the understanding of the OEM-provided engine thermodynamic characteristics for a specific engine type supports the development of EHM modelling, an effective model can also be developed using sophisticated techniques from operational data sets provided by an operator to an EHM service provider.

New technology developments allow the rapid generation of a new engine model from an accurate dataset allowing ASP service providers such as DS&S and Smart Signal to offer their capabilities across a range of aircraft and engine types, offering one-stop shopping to an increasingly dynamic marketplace. This is particularly useful to fast-growing airlines, and supports recent trends of mergers and acquisitions. Such an ASP service can also facilitate shorter term leases of interim lift capacity at an airline, obviating the need to recruit powerplant engineers with specific engine type expertise and facilitating, for example the operations of aircraft fleets such as the A320 family with mixed IAE V2500 or CFM56 turbofans.

Modern engine monitoring systems have been critical in ensuring the smoothest possible service introductions of new engine types by providing rapid, accurate data and in service they have demonstrated major successes in helping to avoid costs. Sophisticated trend monitoring must provide reasonable warning of deteriorating temperature margins or impending failure, thus facilitating timely engine removal and /or defect rectification, with associated cost avoidance from downtime in remote stations and costly passenger disruptions. Too many false alerts can prove disruptive to an operation.

Today, a mature EHM system can typically detect around 60-65 per cent of impending events. Of these, around 10-15 per cent might relate to an impending in flight shut down (IFSD). 'First of type' failures can normally be detected. In addition, aborted take-offs as a result of poor temperature margins or EPR system faults can be avoided and significant reductions in secondary damage through early detections of problems such as guide vane damage can also result. Such systems can successfully detect deteriorations of engine temperature margins, both compressor and turbine damage / deterioration, malfunctions of fuel nozzles, vanes, air systems and valves plus a variety of secondary problems.



EHM service flow diagram

One exciting area which may find application on new generation aircraft is an enhanced vibration analysis system. Extensive research into new technologies suggests that detection rates may be improved by as much as 15 per cent over today's EHM systems.

Industry experts believe that this accuracy of EHM event detection can be improved to more than 75 per cent through the introduction of new technologies, but this will require a careful analysis of the benefits versus the costs of implementation and service provision.

Looking to the future

Where could these future benefits come from? Initial improvements in service will come from enhanced user flexibility in data presentation allied to greater user on-line administration ability plus new (Key Performance Indicators) KPIs. These services may also be integrated with new aircraft health monitoring data and / or inputs from new electronic tech logs (ETL) via a common service portal. Some airlines are also asking for direct feeds into the new breed of powerful web-based MRO systems. For example, the EHM system can monitor the actual engine de-rate usage while an ETL with an aircraft performance module could provide information as to the ideal de-rate that could have been used to enhance engine life. Short term technical improvements include the incorporation of information access via Engine Serial Number, auto FIM references in alerts, auto engine removal reports, start data monitoring and reverse thrust data monitoring.

Future improvements might include Engine System Characteristics trending or the investigation of Search / Pattern matching capability for discrete data (such as BITE codes) and ability to fuse with time series data. Other areas warranting further examination could include the use of case-based reasoning, interfaced directly with a web-enabled display layer for when current "neuro-fuzzy" systems cannot provide diagnosis, enhanced auto alerting quality and higher bandwidth data from enlarged connection capacity.

Since EHM systems have evolved over time, a rearrangement of the current EHM architecture to a New Health Monitoring Analysis Environment could allow a more capable, enhanced, distributable, modular and flexible operating system with lower attendant operating costs.

One exciting area which may find application on new generation aircraft is an enhanced vibration analysis system. Extensive research into new technologies suggests that detection rates may be improved by as much as 15 per cent over today's EHM systems.

Engine health monitoring services have proven invaluable in both reducing operating costs and increasing reliability and availability. Incremental improvements through the application of the latest technology married to new service concepts will see this importance grow. The future could be driven by the successful integration of engine and airframe data through powerful portals into MRO systems and the creation of asset optimisation centres designed to ensure that airlines manage problems before they occur, rather than dealing with the costly consequences of failure after the event.

Key to these developments is the accurate and timely provision of quality data linked to technologies that deliver relevant, actionable information where and when it is needed. 'Management by exception': this is the next frontier in cost reduction.