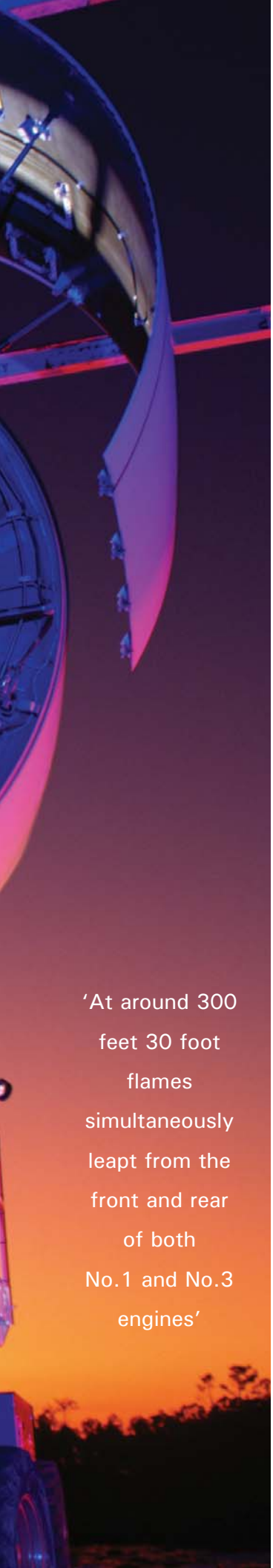

'At around 300 feet 30 foot flames simultaneously leapt from the front and rear of both No.1 and No.3 engines'

Part 1

Managing your PW4000-94

by Oliver Stuart-Menteth, Managing Director, Fintech Aviation Services

The PW4000 engine is one of the most popular engines in operation today, with some 1,900 engines powering over 700 aircraft. It is likely that a significant number of ISTAT members have exposure to the engine in one form or another and are therefore aware of the protracted operational surge problem, which, over the years, has been the subject of numerous modifications.

Pratt and Whitney (PW) has finally developed a modification that should resolve the surge problem once and for all. The final fix though comes at a cost for all associated with the engine. This article is split into two with a review of the current operational and termination requirements presented below, and in the next edition of *Jetrader*, an analysis of the cost of compliance and associated issues.

My association with the PW4000-94s unique problems started in July 1998. Whilst waiting to check out of the CKS Airport Hotel in Taipei, I watched an MD11 climb out after a seemingly normal take off. At around 300 feet 30 foot flames simultaneously leapt from the front and rear of both No.1 and No.3 engines.

A deafening and widespread 'boob-boom' reverberated through the air a short time later. The aircraft gingerly leveled off and completed a tight circuit landing on a parallel runway close to where I was now standing.

Whilst the airport's fire services bolted down the runway I managed to read the registration of the now stationary aircraft. With a heavy sigh, I turned and headed back to the hotel. I had surveyed the aircraft only 24 hours before, but had noticed nothing that could of produced such an event. It was time to do some research.

What causes the problem?

That particular event signaled to PW the need to implement a programme that would resolve, once and for all, the issue of surges on the PW4000-94 inch engine and also manage the risk of dual engine surge.

At the time of the MD11 incident some 150 Group 3 (take off) engine surges had already been encountered, with the first occurring in late 1992. PW identified the primary cause of these problems as deficient margin in the high pressure compressor, specifically the 13th-15th stages. The cause of the deficient surge margin is directly related to the differential thermal expansion rates of the compressor disk and the compressor case. The resulting transient increase of the blade tip blade clearances decreases the margin, which is at its lowest level some 60 seconds after take off thrust has been set. As the thermal stresses equalise throughout the compressor module, the tip clearances reduce and the margin is restored.

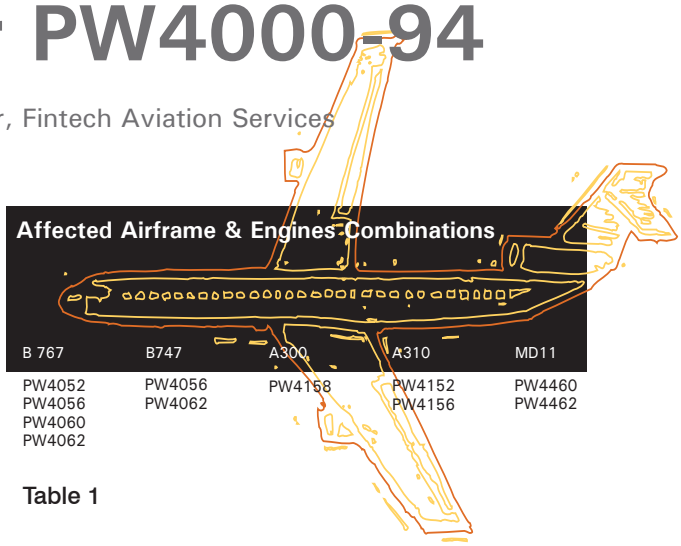

Table 1

Within the PW product range surge events are largely confined to the PW4000-94 inch engine. Table 1 illustrates the various engine and airframe combinations affected.

PW's Response

In response to the initial reported surges, PW reviewed the modification status fleet wide and recommended the incorporation of a particular set of Service Bulletins. These bulletins were collectively known as the New Build Standard (NBS) and were released in mid-1993. In mid 1994 PW released an additional modification relating to the 1st stage turbine vanes and in 1995 operators were advised to incorporate HPC blades that incorporated a ZircOx coating.

Most of the modifications assisted with reducing the occurrence of a surge. However, one particular PW proposed modification relating to the HPC stators actually led to an increase in surges, and forced the OEM to retrofit all new production and converted engines. It was a PR disaster for the OEM, the legacy of which is still apparent in current PW documentation and related FAA directives. Despite the introduction of these recommended modifications into new build and in service engines Group 3 surges still occurred.

The MD11 incident was the first dual engine surge event to occur and signaled to the FAA that a proactive management plan was required. Two Ads were subsequently released in close succession, AD 98-23-08 and AD 99-17-16, the latter requiring adherence to a Group 3 Surge Fleet Management Programme (FMP). The objective of the FMP, which is still in existence today and applies to all 94 inch engines of all modification standards, is ultimately to reduce the risk of a dual and single engine high power surge event. The first revision of the programme required operators to complete certain on and off wing tasks in order to determine that adequate surge margin existed. Whilst the tests and the stagger limitations have been progressively revised, the basic principles have not.

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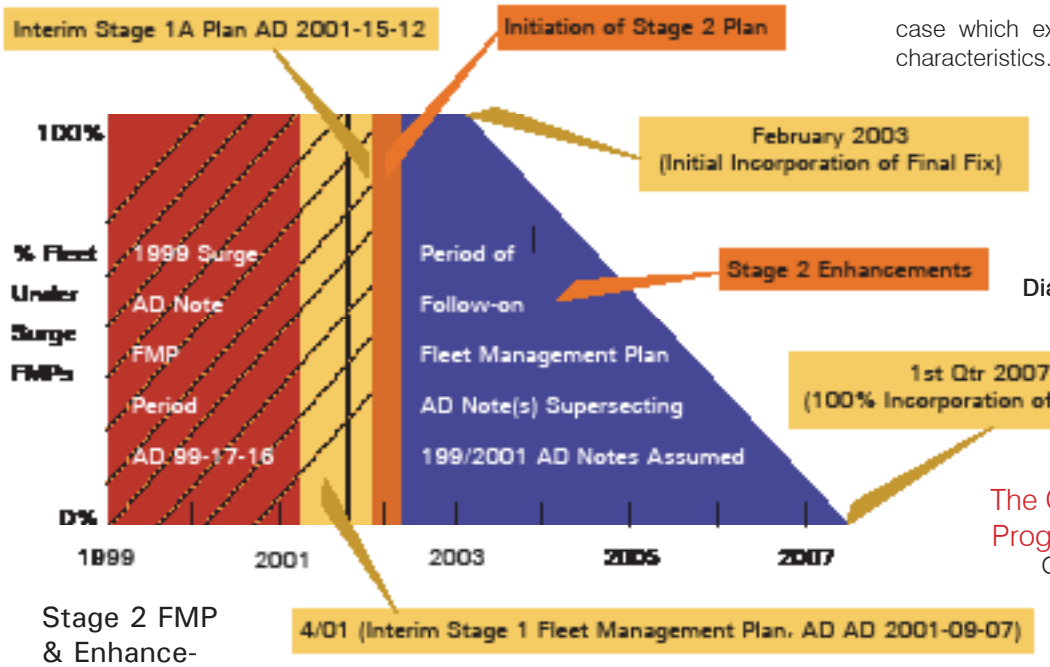

Stage 2 FMP & Enhancements will be in effect until final fix is fully incorporated

In conjunction with the introduction of an engine management plan PW set about devising a modification that would resolve the issue of the surges permanently. During 2001 and 2002 the OEM developed and flight tested a new compressor ring case which exhibited different thermal expansion characteristics. The results were extremely encouraging and the FAA bestowed FAR 25 certification on the installation in February 2003. The first AD 2003-11-18 requiring the incorporation of the ring case became effective on the 7 July 2003.

Diagram 1 illustrates the forecasted FMP and final fix schedule.
Source: PW AOW 18 Oct 01

The Current Fleet Management Programme

Over the past 6 years or so there have been a number of Ads affecting the fleet management programme. The most recent AD 2003-19-15, dated 9 October 2003 covers installation, operational and termination requirements of the PW4000-94 engine on Boeing, Airbus and McDonnell Douglas MD11 series aircraft. It is vital that asset

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managers, owners and lessors associated with the engine have a good understanding of the requirements of this directive, as failure to ensure compliance can only lead to additional cost, illiquidity, and potential loss of revenue. The 20 page AD, which is essentially divided into on-going operational and termination requirements, needs to be reviewed with care.

For the sake of this article it has only been possible to provide an overview of the most prominent requirements:

Main Operational Restrictions

1 Applicable to all engine series – If a Group 3 (take off) surge is experienced, and trouble-shooting does not reveal any anomalies, then the engine must be removed prior to the next flight and the modified compressor ring case incorporated. There is no exception to this rule.

2 All engines that incorporate HPC cutback stators must be withdrawn from service before accumulating 1,300 cycles since new (CSN) or cycles since modification. Prior to this only one engine of this configuration may be installed per aircraft.

3 There are various limitations relating to the Compressor CSN or cycles since overhaul (CSO) imposed on each series engine. The limitations are dependent upon which airframe they are installed upon and the modification status of the engine.

4 If an engine for a Boeing product is inducted into a maintenance shop after the 7 July 2003, or for an Airbus product after the 9th October 2003 or for a MD11 the 8th November 2003 then

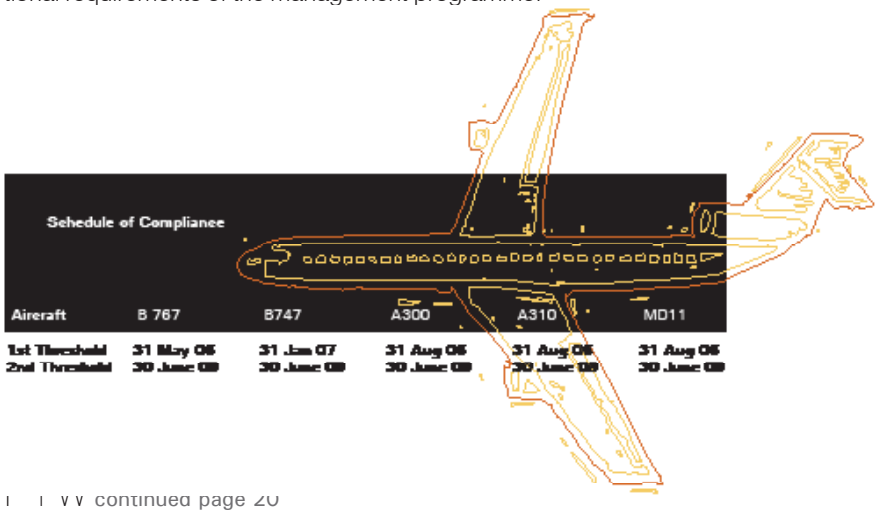
a If the HPC rear module is disassembled, then the RCC rear HPC must be incorporated.

b If the HPC and HPT modules are split, then a HPC module with a CSO of 1,500 cycles or more than the CSN or CSO of the HPT may not be installed.

Compliance Requirements

The FAA has deemed that the incorporation of the RCC is a mandatory requirement. Repeat inspections are not an option. The incorporation of the RCC will negate the requirement to comply with the operational requirements of the management programme.

'The MD11 incident was the first dual engine surge event to occur and signaled to the FAA that a proactive management plan was required'



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Generally for twin engine aircraft, the 1st threshold requires the incorporation of the RCC into at least one engine, whilst applying specific requirements to the other non-RCC engine. For the B747 and MD11 these requirements are more arduous, in that only one non-RCC engine is permitted to be on wing after this date.

The common 2nd threshold date requires all installed engines to have an RCC installed.

Who Needs to Comply with the AD ?

It is a myth to assume that just because a FAA AD has been issued, then all operators world wide of affected equipment will comply with the requirements. Specific legislation concerning the requirements for the incorporation of an Airworthiness Directive are dictated by the National Aviation Authority (NAA) of the state of registry, and no one else. Most, but not all NAAs require an operator to comply with the requirements of the state of type design. However in doing so, the NAA may also issue their own version of the AD, which may contain subtle differences, such as those relating to compliance or dates of effectivity. If your company has exposure to the PW4000-94 in jurisdictions which are not affiliated to the FAA legislative system then verify the proposed action to be taken by the operator. Of course the associated operating or finance lease should contain language requiring the operator to comply with those additional Ads issued by the type design authority, but does it ? And are you enforcing it ? Likewise if the powerplant is operated by an airline that is not particularly experienced with the PW4000-94 then it is prudent to ensure that both parties are in agreement as to the necessary course of action.

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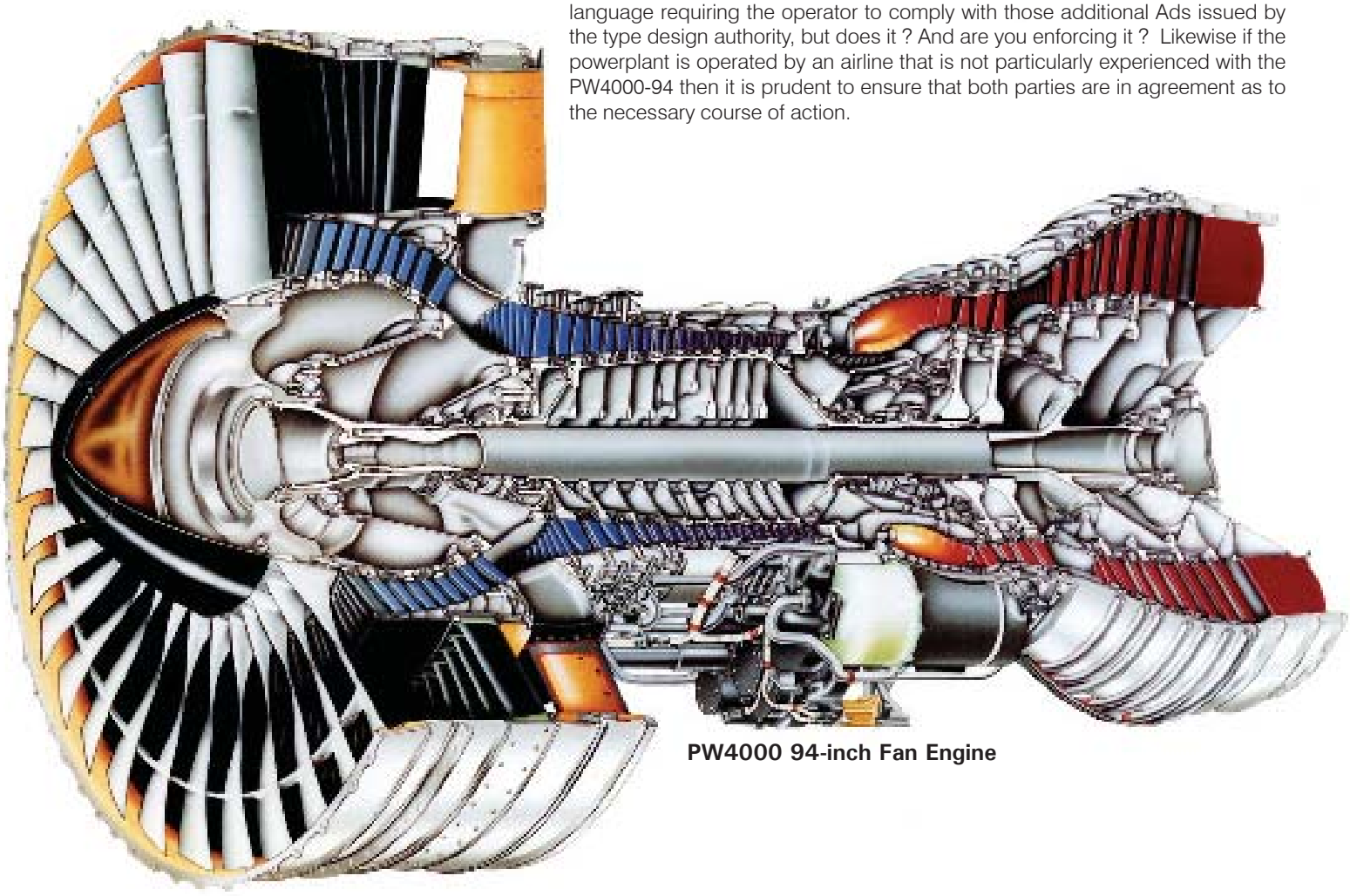

PW4000 94-inch Fan Engine

This year, Pratt & Whitney celebrates its 80th anniversary, powering change since Frederick Rentschler founded the company in 1925.