FPG Amentum

AERO ENGINES:

What to make of today's challenges?

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AVIATION INSIGHTS

ENGINE PROGRAMS CHALLENGES

Commercial Aircraft Engine programs have a complex history. From design to certification through continuous improvements in performance and reliability, they require significant upfront as well as continuous investment to optimize and develop, with many programs seeing decades of service.

In the coming weeks, Pratt & Whitney estimates more than 350 A320neo family aircraft will be subject to forced groundings due to Airworthiness Directives (AD) issued by the Aviation Authorities, which require engine removal and piece part inspection of a number of affected parts. This issue is the latest in a series of problems to plague the early years of the service. Apart from near-term disruption of operations, there are long-term considerations of the economics of operation and maintenance of new engine types. What can we learn from history?

INTRODUCTION

Aircraft engine technology has become very competitive among the four main incumbents (Pratt & Whitney, Rolls-Royce, CFM, and GE). There are ever increasing by-pass ratios, advanced materials, cooling technologies, and fundamental engine architecture changes. These changes are primarily focused on improving fuel efficiency and performance, but also reliability and durability, to meet the increasing demands of operators and owners. While manufacturers strive to improve their products and remain competitive with the introduction of new technologies this must also come with the challenge of making sure any new technologies introduced have reached the desired level of technological maturity.

The increase in the prevalence of maintenance cost risk transfer products, such as power by the hour agreements in recent years has aligned both operator and manufacturer interest in creating a reliable and durable product. However, historically it is not unusual for new engine types to suffer numerous reliability issues associated with the entry into service. These teething issues can cause significant disruption and cost to operators.

The engine OEMs have typically sought to address these problems relatively quickly, given the significant reputational and financial exposures at stake. It is easy to forget the often-problematic introductions of previous generation engine types.

Problems have plagued the entry to service of all aircraft engine programs to a greater or lesser degree. It approximately cost 1 billion USD and took nearly seven years to develop the original CFM56 engine model – now considered one of the most successful engine programs in history. Initial challenges were related more to the political sensitivities of GE (US) collaborating with Snecma (now Safran, France) based on national security risk. The first CFM56 powered flight took place in 1977 but no orders were placed until United Airlines operated its first CFM56 in 1982. Teething issues were experienced during the early years of the CFM56 engine including several blade failure incidents. Engine fan blade separation caused by vibrations at high altitudes (>3,000 m) contributed to the first total loss of a 737-400 and until the issue was solved, the full fleet of 737-400s was grounded. There was also the highly publicized problem of blade fractures in the High-Pressure Turbine (HPT) of the CFM56-7B engine. The blades in the HPT, under high thermal stress and fatigue loads, could fracture causing in-flight shutdowns of the engines and significant secondary damage to the engine. Multiple Service Bulletins (SB) were issued to solve the problem such that today, between the 5B & 7B engines types there have been over 15 different HPT blade standards.

Today, more than 20 aircraft types have been powered by CFM, but from its very beginning there were many technical challenges, most of which are now well forgotten; indeed, it is not often appreciated that the CFM56 has seen over 10 different upgrade packages to date. According to CFM's own data, the CFM56-5B/7B engine program took over 10 years to reach maturity at which point the time on wing and reliability metrics had improved considerably, and time between shop visits had more than doubled in the first 10 years of service.

Similarly, the introduction of the V2500 was not without its own issues. Initially the V2500-A1 had rotor bow issues (non-uniform cooling of metal components in the compressor causing bending of the compressor rotor drum) which required several modifications. This and other performance shortfalls ultimately led to the development of the V2500-A5 version.

The introduction of the PW1100G-JM engine to power A320-NEO aircraft in January 2016, was followed by a significant number of high-profile technical issues: engine start delays, combustion chamber degradation, no. 3 bearing carbon-air seal problems, fan blade defects, and High Pressure Compressor (HPC) 'knife-edge' seal cracking. P&W has managed to introduce numerous improvements to address each of these issues, sometimes with multiple iterations, and some with quicker solutions than others. Some of the earliest engines have had several 'quick turn' shop visits to incorporate each of these improvements or other corrective actions. However, just as Pratt & Whitney was starting to see light at the end of the tunnel along came another issue.

P&W POWDER CONTAMINATION

The latest – and arguably the most disruptive – issue faced by P&W, was first identified on a V2500 powered A321 in March 2020. The event, described as an uncontained failure, led to a rejected takeoff incident. The engine failure was localized on the stage 1 disk of the HPT and was found to be caused by material anomalies introduced during the manufacturing process; the event was followed immediately by an emergency Airworthiness Directive (AD 2020–07–51) issued by the FAA. This led to the removal from service of several V2500 engines.

After an event of a similar nature on a PW1100G engine, P&W identified powder metal contamination affecting the V2500 part supply may also impact the GTF engines, a subsequent AD (2021–19–10) required the removal from service of certain PW1100G-JM engines in 2021. Further analysis led to AD 2022–19–15 requiring performing specialist ultrasonic inspections (USI).

Another incident, in December 2022, a PW1127GA–JM powered A320NEO aircraft, experienced a failure in the HPC 7th stage which led to engine shutdown and rejected take-off. Further investigation led to P&W announcing that a total of five different parts within the engine could potentially be affected by powder metal contamination during production. The total number of engines requiring inspection now exceeds several thousand engines currently flying, or indeed still in the production line or overhaul process

As a result of powder metal contamination, fleet management is also required on the PW1500G engine (powering A220-100 and A220-300) and P1900G series engines (powering E190-E2 and

W195-E2). New learnings from the powder metal contamination have led to new reduced life limits for affected parts from 12,500 FC to 5,000 FC for 33K lb of thrust engines (A321s) and 7,000 FC for 27K lb of thrust engines (A320s). The latest AD was published on 9 January 2024.

P&W has stated they are confident that they are addressing all the powder contamination issues at this stage and have solutions in place to i) identify non-conforming parts during the manufacturing process and ii) replace the suspect parts. The more significant challenge consists of implementing the fleet management plan in accordance with the airworthiness directives to inspect and replace the suspect parts. This fleet management plan will require an unprecedented number of engine removals and shop visits in a short timeframe and is predicted to cause significant disruption.

P&W IMPACT ON GLOBAL FLEET

At the end of January 2024, according to Cirium data, there were 1,057 in service and 415 in storage A320NEOs and A321NEOs powered by PW1100G-JM engine. The in-storage fleet has been consistently increasing since August 2023. The stored fleet leveled off at ~300 aircraft in December 2023 but increased to over 400 at the beginning of 2024. This is likely the level of saturation for MROs. It is plausible to assume that the majority of their engines are in shops to address the powder issue.

This means that 28% of the A320NEOs and A321NEOs powered by the GTF are not in service. This figure is moderately higher than the widely circulated estimate that 350 aircraft (700 engines) are expected to be grounded at one time from now on until 2026. This would bring the out-of-service fleet of A320NEOs and A321NEOs powered by the GTF to nearly 25%.

The high percentage of out-of-service GTF powered NEOs creates a global shortage of narrowbody aircraft. As current issues and the current fleet take precedence, there will also be delivery delays of new aircraft, and, consequently, an increase in demand for current aircraft technology. Non-impacted aircraft will experience a positive effect (lease rates strengthening, robust residual values, strong market activity). Positive effects for non-impacted aircraft have already been noted in lease renewals. Airlines will likely continue looking for lease extensions or additional aircraft to meet growing demand for the next 2-3 years, or maybe longer, depending on how long it takes P&W to fix the problems.

P&W FLEET MANAGEMENT

Many engine inspections are general visual examinations that can be accomplished with a borescope or without disassembly of the engine. The current issue with the PW1100G-JM requires engine removal and shop visit to access each of the affected parts as required. Once the part is accessible it requires an ultrasonic inspection using special equipment and procedure. There is currently only limited capability worldwide to conduct such inspections adding another constraint to the system of returning engines to service. Pratt & Whitney has plans to increase inspection capacity but clearly, this will take time and has its own inherent risks.

P&W is advising that it could be as late as 2026 before the AOG situation recovers as the backlog of engines is removed and parts assessed. There is a clear risk that it could take well beyond this timeline given the numerous elements required to implement a successful fleet management plan. The risk arises from multiple variables – shop capacity, parts supply, turnaround times, spare engine levels and many more.

Shop capacity is a major issue for solving the powder challenge. Currently, P&W has 9 established MROs. Before the latest powder contamination issue, MROs were already known to struggle for capacity. Many slots are booked months in advance and availability is reduced. MROs worldwide have struggled with reduced parts supply and manpower in the wake of the COVID-19 pandemic. Also, not all MROs have the capability to perform inspections on the PW1100G-JM engines yet. P&W plans to add six more maintenance centers to its network in 2024. Additional maintenance centers may not necessarily translate immediately into material help with the number of GTF engines that need to be inspected given the time it takes to ramp up production and gain experience. Increasing shop capacity remains key to is critical to P&W's ability to recover all AOG situations by 2026.

Parts supply will also be critical to maintaining turnaround times in the shops, not just for scheduled removals and those parts required to be inspected and replaced per the ADs but also for other parts exposed during the shop visit and requiring repair or replacement. An engine requires all its parts to be fitted before entry back to service and a delay on a single part can hold up the entire build and test line. This also has the knock-on effect of subsequently delaying the induction of the next engine in line, compounding already strained shop capacity.

Spare engines - P&W made considerable investments in lease engines in recent years. Pratt &Whitney's engine leasing unit (PWEL), has a fleet of over 300 PW1100 engines. PWEL's fleet grew from roughly 30 engines in 2016 to 300+ in 2020. This fleet, in addition to airlines' own spare engines, has seen phenomenal growth due to the number of entry into service issues requiring early shop visits during the early years of the program. The PWEL fleet is expected to further grow from 2024. This fleet plays a big role in addressing demand from affected airline customers. Clearly, P&W's ability to increase the spare engine pool is dependent on diverting new engines from the production line that otherwise were planned for new aircraft deliveries. Difficult conversations with customers and Airbus about where to allocate engine deliveries can be expected.

Turnaround times have been reported to vary between 150-180 days from wing-to-wing and P&W is working on improving the turnaround time. A potential challenge may be the slower turnaround time in the new MRO centers. An MRO new to the PW1100G-JM engine could take several years "learning the engine". The new maintenance platforms will need accelerated learning. Regardless, in their first year of activity, the MROs new to the network might only provide inspections on a small number of engines compared to an already established platform. In the future, P&W intends to "implement universal shop guidance" and to "empower shops to make decisions more quickly" which should improve turnaround times.

CONCLUSION

From the airlines' perspective, the most concerning issue is the undersupply of aircraft the market will experience while these engines are overhauled. However, lessors and owners may benefit from the situation as demand for their assets has increased, extending the life of older assets, and leading to lease extensions, and buoyant lease rates. For investors, it is critical to understand the period for which this situation will last. At this stage, it is unclear how long it will take the network of MROs to tackle the current powder contamination problem.

It is likely that whilst numerous PW1100G powered aircraft will continue to be grounded for the next couple of years there are limitations to the ability to expand on the current network that can overhaul PW1100G-JM engines, the new MROs will have slower turnaround times, the future ADs may be even more restrictive or that the spare engine pool will not grow in a meaningful way such that Pratt & Whitney may struggle to deliver on their plan.

On the positive side, the overall MRO network capacity is growing, turnaround times are constantly being improved and the fleet of spare engines is also growing.

P&W needs a concerted effort to increase shop capacity, reduce turnaround times, increase the spare engine pool, and speed up learning the engine in its expanded MROs to improve on its 2026 forecast of zero AOGs.

In the same way past technical challenges are now well forgotten, and so shall be the current issues; in the long run Engine and Airframe Manufacturers are well placed to resolve issues and improve their products to meet industry expectations.

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