



The Power Behind the Plane: Keeping APUs Running



One of the major operational disruptions for any airline is unscheduled maintenance. When a system like the auxiliary power unit (APU) is involved, the impact can extend beyond a maintenance task to affect aircraft availability and operations. Though the APU

is mostly used for ground operations, it is needed to keep both the electrical and pneumatic systems functional during an in-flight emergency, like the loss of engine power. Being a critical system, its continued serviceability is also a key factor in maintaining safe flight operations. Its availability during maintenance operations can also reduce turnaround time for operators.

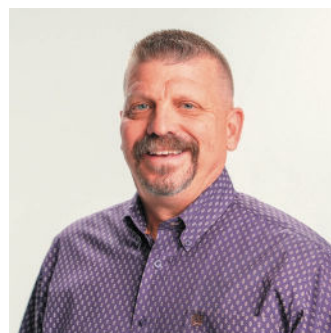
Hence, airlines aim to maintain APU reliability to maximize on-wing time and reduce aircraft downtime. Even though this seems like a maintenance issue, the challenge goes far beyond just keeping the APU serviceable for operators.

In-Shop APU Maintenance

An APU is unlikely to require major repairs because of a single in-service failure. In-shop maintenance typically arises from a gradual decline in operational performance over time, alongside



Ray Boyd
Honeywell Aerospace



Jason Evans
MK Test Systems

recurring faults, which can make continued operation impractical and uneconomical.

"One of the key indicators is an elevated exhaust gas temperature (EGT), which is a known predictor of maintenance needs," says Ray Boyd, general manager, narrowbody APU product line, Honeywell Aerospace.

However, elevated EGT is just one of many reasons an APU might

be removed for maintenance. As APU deterioration is not always straightforward, other system parameters, such as increased oil consumption, leaks and contamination, the presence of foreign object debris (FOD), damage to internal drive shafts, abrupt changes in start performance, and unusual vibrations, can also signal the need for a shop visit. A single abnormal indication is not sufficient reason for removal.

"Vibration, abrasion, contamination and mechanical damage can all contribute to insulation degradation, resulting in increased leakage current in APUs," says MK Test managing director, Jason Evans. "If left undetected and not addressed immediately, these can eventually lead to functional failure."

This is why early detection is important. If deterioration is diagnosed before functional failure, maintenance teams can determine the best corrective actions to avoid an unplanned disruption to operations and maintenance.

The Cost of an Unscheduled APU Removal

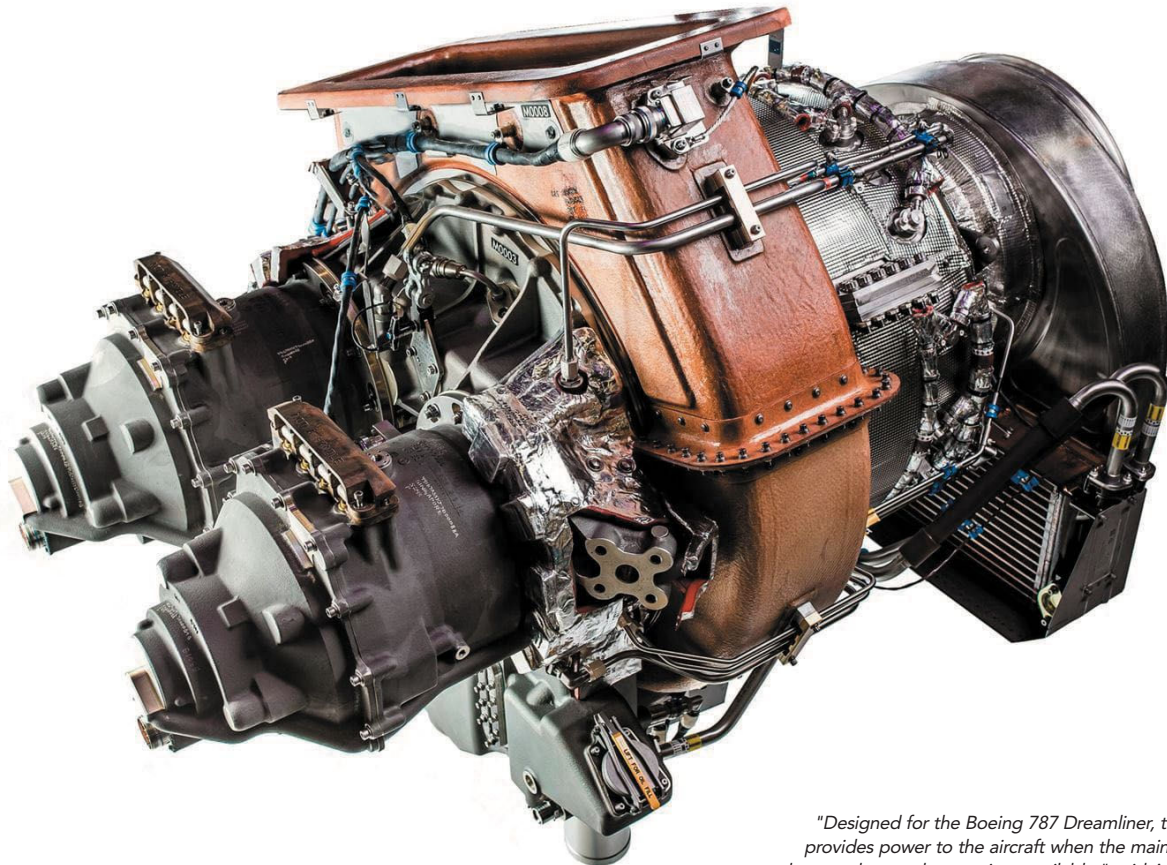
The impact of abruptly removing an APU from an aircraft is complex, affecting maintenance reliability, logistics and finances. First, the operator has to account for the operational disruptions

that arise as a result of an unscheduled shop visit. An unscheduled repair will affect aircraft availability due to unplanned downtime, an increase in the demand for manpower, logistics requirements, and the financial pressure to restore serviceability.

In certain instances, the aircraft might be able to operate under the provisions of the Minimum Equipment List (MEL), within a specified timeframe, often based on the aircraft type and applicable maintenance procedures. This allows operators to continue operations rather than having to ground the aircraft unexpectedly. Through the MEL, a deadline is given, with the possibility of an extension if needed, to carry out the required repairs. Nonetheless, this does not give operators the freedom to continue flying without a functional APU, nor does it fully remove the impact on operations.

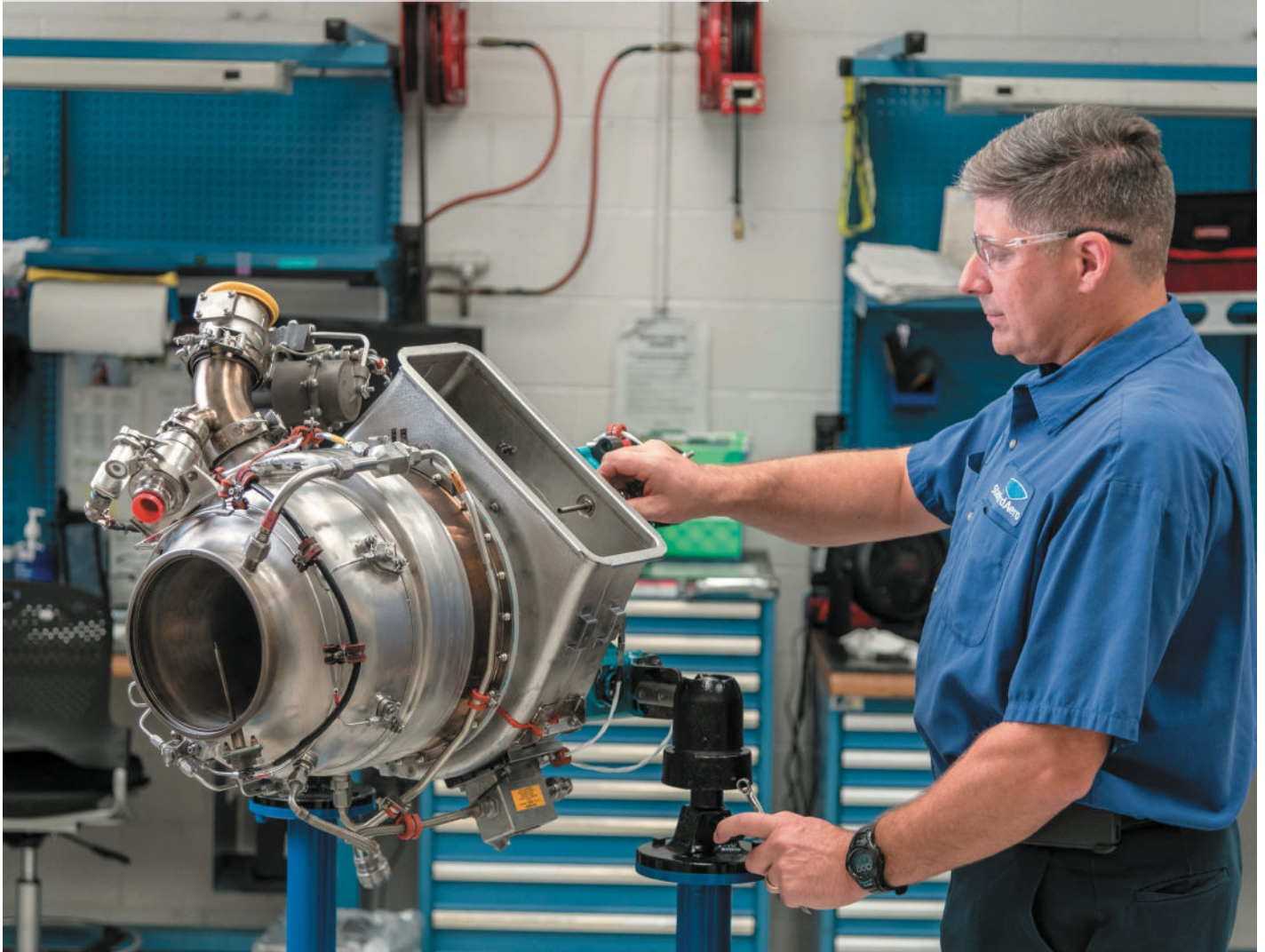
Pratt & Whitney Canada confirms that most of its APUs are for commercial aircraft operated by scheduled airlines for whom dispatch reliability is always critical.

For an extended-range twin-engine aircraft, a reliable APU is important to maintain the Extended-range Twin-engine Operations Performance Standards (ETOPS) approval. In contrast, heavy long-haul aircraft with four engines, like the Airbus A380 or



"Designed for the Boeing 787 Dreamliner, the APS5000 APU provides power to the aircraft when the main engines are shut down and ground power is unavailable," said Anthony Rossi, vice president, customer service, Pratt & Whitney Canada. "Additionally, the APS5000 simultaneously powers twin electric starters for the main engines making it vital to overall dispatch reliability."

StandardAero's Scott Arms, VP Honeywell Commercial Programs at StandardAero said predictive maintenance is giving operators advanced warning and the ability to plan. StandardAero image.



B747, are not affected in this manner. They are legally permitted to fly across the Pacific Ocean under strict regulations established by global aviation authorities.

Ground operations are also affected by an unserviceable APU. APUs are used to start the engines before flight and they provide air conditioning for passengers when boarding and deboarding. When an APU is unserviceable, there is an increased reliance on ground power units (GPUs) and other related ground equipment to perform these functions.

The operator is still required to schedule the required maintenance tasks within the timeframe allowed for rectification, taking into account the aircraft's routing, operating requirements and the availability of replacement components for the aircraft.

The financial implications of an unscheduled APU removal extend beyond the maintenance and repair costs. For every hour the aircraft is grounded, the airline is losing valuable aircraft utilization time and potential revenue from scheduled flights. This disruption can also result in rescheduling flights, additional operational costs and possible refunds or compensation for delayed and cancelled flights. Meanwhile, the airline might have to put more workload on other aircraft in its fleet to meet the affected flights, which in turn will increase their operating time

and result in less flexibility for subsequent flight disruptions.

APU Testing, Troubleshooting and Fault Detection

Testing an APU involves a combination of manual methods and automated systems to assess the unit's functionality and performance. Using these systems, engineers can evaluate the working condition of each component within the unit, identify abnormal indications and determine the root cause of any fault or malfunction. Automated testing can significantly accelerate this troubleshooting process, especially when isolating electrical faults, according to Evans, who further cited the example of the pin-to-pin continuity check on a wiring harness in the Honeywell 331-350 APU Maintenance manual.

"When this process is performed manually, every connection must be verified individually," said Evans. "Even allowing just five seconds per measurement, you're already looking at around 380 seconds of testing time and that's before considering documentation and reporting requirements. With an automated test system such as MK Test's Automeg, that same harness can be tested for continuity, resistance and short circuits in approximately 20 seconds, with every measurement automatically logged and reported."

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Not only do these systems speed up troubleshooting, but they also ease the pressure of reporting and documentation, which is mandatory in aircraft maintenance.

Automated testing is useful in identifying deterioration before it becomes a hard failure. This forms one of the most valuable benefits of using computerized systems in troubleshooting faults such as increasing resistance, intermittent connection and insulation degradation in the APU.

"Using a four-wire (Kelvin) measurement technique, which is a standard feature of MK Test's Automeg systems, very small changes in resistance can be detected down to the milliohm level," Evans adds. "When these measurements are recorded during scheduled maintenance intervals, it becomes possible to monitor trends over time rather than simply assessing whether a component passes or fails on a given day."

Engineers assess the frequency and nature of these patterns, the rate of decline in performance and the likelihood of the need for an unscheduled removal later on. This helps predict the exact fault and determines the appropriate maintenance actions to prevent failure in service.

Predictive Maintenance in APU Testing

Predictive maintenance is essential in maintaining the serviceability and reliability of APUs. It relies on condition and health monitoring, which is the basis of this maintenance approach. Condition monitoring allows operators to track important APU performance parameters while in operation and identify indications that are not apparent in regular inspections.

For this, Honeywell Aerospace adopts the Predictive Trend Monitoring and Diagnostics (PTMD). This technology continuously monitors APU performance and alerts airlines to potential maintenance needs before failure occurs. Operators can see these trends, and when monitored over time, they can identify the abnormal indications which may be a sign of ongoing deterioration.

"The real benefit of predictive maintenance for APUs isn't predicting the exact day of service failure, but giving the operator enough warning to plan maintenance around the aircraft's schedule," said Scott Arms, vice president, Honeywell Commercial Programs for StandardAero.

Health monitoring takes this a step further by combining data obtained from the APU with that of its operating environment. Instead of relying only on the APU's performance data, maintenance personnel can monitor several parameters in other related systems to determine the APU's earlier operating data; if not, they can determine if they need to investigate the changes.

The operators can use these health-monitoring tools to monitor the APU's performance with respect to other aircraft systems during operations and create a baseline for future comparison. Thus, the bottom line of predictive maintenance is the action taken after analyzing these data. Once current datasets begin to deviate from ideal operating parameters, engineers can examine the data, decide the root cause and determine the best maintenance action to be taken.

"Our APUs are equipped with health monitoring tools that allow operators to monitor the APU performance. Operators can use this data to implement predictive maintenance actions based on their expected utilization and operation," according to Pratt & Whitney Canada.

This is why condition and health monitoring is important. They help operators differentiate a one-off incident from a potential

reliability problem. By monitoring these indicators, operators can detect declining APU functionality using sensors and generated aircraft data. This also assists maintenance teams in making safety-critical decisions before failure occurs. Instead of waiting till the APU fails, operators can monitor performance indicators and determine when the component is due to be removed and coordinate a shop visit with scheduled maintenance to avoid unnecessary aircraft downtime, allowing more effective management of maintenance scheduling.

Predictive maintenance is more than just reacting to a fault. Maintenance personnel no longer need to wait till the unit breaks down before maintenance tasks can be done to prolong the service period. Rather, performance data can give maintenance personnel an indication when intervention may be necessary and take corrective action, which can extend the APU's time-on-wing.

Keeping the APU On-Wing Longer

The goal of every operator is to maximize the APU's serviceability, keeping it within the required performance range for safe operations. From an expert's perspective, Arms highlights that understanding and monitoring how the condition of the APU changes over time is the primary factor to extend the on-wing time rather than simply tracking hours. This requires consistent maintenance practices, regular inspections, oil and chip monitoring and paying attention to start performance, which is part of their processes at StandardAero. These will help operators identify problems on time before they become major failures. Manufacturers also have a role to play in this.

Modern APUs are now being fitted with new technologies to enhance APU efficiency and extend time-on-wing. For example, in the Honeywell 131-9 narrowbody APU, the High Efficiency Mode (HEM) is designed to improve both fuel efficiency and time-on-wing.

"HEM offers an additional time-on-wing of 1,500 hours, about 2% fuel savings to the operators that enable this upgrade and delivers 9% better baseline reliability than the next-best competitor due to design," Boyd adds.

These developments show that extending APU time-on-wing is not reliant on only one maintenance practice. Instead, it involves a combination of technology and strategies, with these improvements made by both the operator and manufacturers.

APU Turnaround Time, Repair and Replacement

Turnaround time is also an important factor to consider when determining how long an APU stays on-wing. Many factors such as the inspection findings, work scope and availability of parts and manpower can determine the extent of the turnaround time.

Based on this, not every APU maintenance task will require a shop visit and not all shop visits require an overhaul. Parts of this unit are assessed to determine their individual serviceability, and decisions are made on whether to repair, overhaul or replace in accordance with applicable manuals.

To improve turnaround and parts logistics, Pratt & Whitney Canada confirms, "We continue to invest in our supply chain network and in new hires and new capabilities for our MRO facilities around the world to meet our customers' demands."

To minimize operational disruptions, having a serviceable APU ready for immediate replacement reduces downtime,

speeds return to service, and eases pressure on other available units in the fleet.

Software Takes Aim at APU Turnaround Time

The inherent unpredictability of APU maintenance makes the shop visit particularly challenging to schedule, staff and price. Unlike routine component work, teardown can quickly reveal problems that dramatically alter the original workscope.

"APU is like a self-contained, mini gas-turbine engine, and hence, shares all the complexity of an engine MRO," says Manoj Singh, chief customer officer at Ramco Systems. Teardown findings can generate additional work across fuel, pneumatic, electrical and mechanical systems, changing requirements for labor, parts and testing as the shop visit progresses. APU article-AMM -Ramco inputs

Some of the greatest risks to turnaround time occur at inspection, during parts procurement and in the test cell. NDT inspections can uncover previously unknown hot-section damage; shortages of high-value components and life-limited parts can stall reassembly; and a failure to meet EGT margins or vibration limits during testing can require additional teardown, balancing and retesting. APU article-AMM -Ramco inputs

Increasingly, MRO software is being used to anticipate those problems rather than simply record them. Historical teardown data, operating conditions and APU type can help forecast potential non-routine findings, allowing planners to pre-stage parts and technician capacity. APU article-AMM -Ramco inputs

"Pre-induction visibility lets planners pre-stage materials via a centralized marshalling hub, accelerating execution and significantly reducing Turnaround Time (TAT)," Singh says. APU article-AMM -Ramco inputs

Digital systems can also address a less obvious source of lost time: customer approvals following unexpected teardown findings. Software can connect a newly discovered defect with contract requirements, estimated costs and parts availability, then present that information electronically for customer review.

"The customer receives real-time visibility into the exact teardown findings, cost changes, and parts availability," Singh says. Customers can then approve or amend the revised workscope electronically, potentially eliminating days of back-and-forth communication.

Beyond APU Reliability

As airlines move towards more sustainable operations, the focus is gradually shifting from corrective APU maintenance to a more proactive approach. Instead of waiting till a component fails in service, preventive maintenance measures are now being taken before extending the APU service periods whilst reducing aircraft downtime. This approach is not just a maintenance goal. It is a business strategy for fewer unscheduled removals and reduced disruptions for better operational reliability. This transition from responding to failures to managing operational deterioration is the key to keeping the APU on-wing for longer while maintaining aircraft availability and operational reliability. **AM**

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