

temperatures at high altitude. These design and test elements do not assure a level of reliability that is equivalent to that based on service experience. Instead, they result in an acceptable level of inherent design reliability from which we can successfully manage ETOPS fleet safety once the airplane enters service.

The fourth element, "demonstrated reliability," provides the FAA with a standard by which to judge a design against existing ETOPS-approved airplanes. This gives the FAA a standard from which to withhold ETOPS approval from airplanes that experience significant failures during certification testing, demonstrating that they are not suitable for ETOPS. However, it does not by itself guarantee that designs showing no significant failures during flight testing will have adequate reliability for ETOPS.

To manage fleet safety after ETOPS approval, we rely on the fifth element of the ETOPS special conditions. Paragraph (f) of the special conditions requires a problem tracking system for the prompt identification of those problems that could impact ETOPS safety. The FAA uses this enhanced problem reporting system to work with the airplane and engine manufacturers to aggressively manage and correct significant design problems identified after ETOPS approval. This requirement is the "catch-all" for those design flaws that are not caught by the other elements of the special conditions during airplane design and testing.

The first in-service inflight shutdown of the Model 737-700 variant of the 737NG did not occur until the fleet had accumulated approximately 30,000 engine-hours. The FAA could not have expected that a complete 1000-cycle airplane demonstration test would have had a better chance of discovering the types of problems that occurred in service on the 737NG than the nearly 30,000 hours accumulated on multiple airplanes and engines prior to the first inflight engine shutdown. While significant propulsion system failures occurring during type certification testing, including the additional testing required by the ETOPS special conditions, may indicate that a design is not yet ready to enter ETOPS service, the 737NG experience shows that the reverse cannot be stated with a significant degree of confidence. A lack of significant failures during certification testing does not in itself assure an ETOPS-suitable design at entry into service.

The Model 777 experience shows that a relatively small fleet can be managed successfully during the initial service

period based on the data provided by the enhanced problem tracking system required by special conditions paragraph (f). The 737NG experience shows that a larger fleet may require a much more resource-intensive fleet management program. However, had the 737NG received its ETOPS approval as originally proposed prior to its first inflight shutdown in service, the problem reporting system that Boeing had in place gave the FAA timely identification of the problems causing inflight shutdowns so that we could have required appropriate corrective action through the airworthiness directive process to maintain ETOPS safety. Such airworthiness directives could have required the operators to incorporate design changes prior to further ETOPS flight or withdrawn ETOPS approval.

Although we cannot be certain that an airplane approved for ETOPS under the special conditions will have the same maturity at original type certification as an airplane that we have approved based on service experience, our experience with the Model 777 and the 737NG confirms that the five elements of the special conditions, in conjunction with the FAA's normal safety oversight processes, adequately compensate for that uncertainty.

The changes to the engine demonstration test and the airplane demonstration test include enhanced post-test inspection requirements and are intended to address our experience with the original ETOPS special conditions, which identified several shortcomings in the original test requirements. These changes are needed to more clearly focus the testing on the objective of exposing the engines and airplane to those operating conditions that give us the best chance of identifying underlying major design flaws that could jeopardize ETOPS safety in service. These changes provide a better evaluation of the design than the existing requirements, including the 1000-cycle airplane flight test as previously conducted.

The FAA therefore is changing the purpose of the airplane demonstration test requirement of paragraph (e)(7) from a demonstration of reliability to a demonstration of airplane capability under the types of ETOPS operational and diversion scenarios discussed in this document. The requirements of that airplane demonstration test have been changed accordingly.

#### **Aged Engine Requirement**

In response to Boeing's request, the FAA is deleting paragraph (e)(7)(ii), which currently requires the installation

of the engine and propulsion system from the 3000-cycle engine demonstration test required by paragraph (e)(6), or another suitable aged engine, on the 1000-cycle demonstration test airplane for a minimum of 500 cycles. Boeing provided the following information in support of its request for deleting the aged engine requirement.

Review of the aged engine data from the baseline Model 777 program showed that the nature of the findings, which occurred on the aged engines, was not related to the aging of the engines. Instead, the findings were related to the variation that occurs during manufacturing, assembly, etc. This lesson learned on the aged engines is consistent for each engine manufacturer's baseline Model 777 ETOPS test program.

The lack of findings related to the aging of an engine in the ETOPS flight test program has been demonstrated three times. Based on this consistent demonstration, there is no further need to maintain the requirement for an aged engine in the flight test program. Additionally, flying more airplane/engine combinations will provide increased opportunities for evaluating potential problem areas.

Boeing reported nine events (EE-1 Reports) which occurred during the aged engine portions of the 1000-cycle tests for the three baseline engine types, with an explanation of why the aged engine requirement was not necessary in order to identify each failure. Boeing stated that the lack of any EE-1 reports from the post-test inspections is an indication that there were no significant findings from the aged engine testing.

#### *FAA Analysis of Boeing's Proposal*

The original intent of the aged engine requirement was to expose the 3000-cycle test engine, or equivalent, to inflight conditions that cannot be simulated in a ground test environment. This would further validate the propulsion system design out to an age beyond 3000 cycles. Boeing data available at the time the ETOPS special conditions were developed indicated that 95% of all new significant failure modes occur on airplane propulsion systems with 3000 cycles or less. That concept is still valid. The lack of specific findings on the aged engine during the 1000-cycle airplane validation test only confirms the validity of the Reliability Assessment Board's conclusion that those baseline Model 777 engine installations were suitable for 180-minute ETOPS. A number of significant events during the