

Boeing stated in the 737-700's 120-minute ETOPS Airplane Assessment Report that the fleet reached the 15,000-hour mark during the month of April 1998. At that time, there had been no inflight shutdowns in service. However, on May 9, 1998, before the FAA had completed its assessment of the airplane for ETOPS approval, the first inflight shutdown occurred. A second inflight shutdown occurred during the month of May, and the fleet exceeded the accepted 120-minute ETOPS standard of .05 inflight shutdowns per 1000 engine hours. Three inflight shutdowns occurred in June 1998, and one in July 1998. The peak inflight shutdown rate during this period was .085/1000 hours at the end of June 1998, which clearly did not meet the minimum standard for ETOPS type design approval.

The six engine inflight shutdowns were caused by three different failure root causes. Boeing and CFMI, the engine manufacturer, undertook aggressive actions to correct each of these design problems as they occurred. The high rate of fleet hourly accumulation during this period, however, resulted in new ETOPS reportable events occurring faster than the known problems could be corrected. This delayed FAA consideration of the 737-700 for ETOPS approval until the problems were brought under control. A consequence of the high rate of fleet hourly accumulation was that, with no additional inflight shutdowns, the inflight shutdown rate decreased rapidly and was within the ETOPS type design approval standard by the end of 1998. The FAA approved the 737-600/-700/-800 (737NG) for 120-minute ETOPS approximately one year after entry into service with over 300,000 engine-hours of service experience and an inflight shutdown rate of .020/1000 hours.

Conclusions From Comparison of 777 and 737NG

In comparing the 737NG experience with that of the 777, the FAA observes that there is a fleet hourly accumulation rate above which aggressive problem management to qualify for early ETOPS certification may become resource prohibitive. Therefore, when certifying an airplane/engine combination that will be entering service with a high production rate resulting in a rapid accumulation of engine hours, manufacturers may find it more cost-effective to use the service experience criteria of AC 120-42A than to follow the rigorous requirements of the early ETOPS process.

As stated earlier, the 777 ETOPS special conditions were designed to

“result in a level of airplane reliability that is equivalent to the level of reliability previously found to be acceptable based upon service experience.” As previously noted, the current 777 ETOPS special conditions consist of five main elements needed to provide adequate compensation for the service experience normally required for 180-minute ETOPS eligibility described in AC 120-42A. No single element is considered sufficient by itself, but the FAA has found that the five elements combined provide an acceptable substitute for actual airline service experience. The five elements are:

1. Design for reliability.
2. Lessons learned.
3. Test requirements.
4. Demonstrated reliability.
5. Problem tracking system.

Even though the overall objective is a level of airplane and propulsion system reliability that is equivalent to that achieved through service experience, we considered the uncertainty of actually achieving that goal in the development of these special conditions. The first three elements focus on designing an airplane to eliminate sources of engine inflight shutdowns and diversions to the greatest practical extent. This is accomplished by an overall design philosophy to preclude sources of engine inflight shutdowns and diversions using the manufacturer's experience with earlier designs to identify successful and unsuccessful design features. The additional testing required by the special conditions focuses on exposing the design to conditions that in the past have contributed to engine failures, such as high engine vibration or repeated exposure to humid and inclement weather on the ground followed by long-range operation at the extreme cold 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 special conditions elements during airplane design and testing.

The first in-service inflight shutdown of the 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 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