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# Going the Distance: Extended-Range Operations Drive Safety, Performance

Much like characters in a 1940s-era adventure film, early commercial airplane pilots globe-hopped from place to place to reach their final destinations, following routes that, while interesting, were anything but direct. Airplanes hugged coastlines, skirted mountains and avoided rugged and isolated terrain where they could not land.

Prior to1985, international aviation regulations required two-engine airplanes to fly no farther than 60 minutes away from an airport at which they could land in case of engine failure. Tri-jet models such as the Boeing 727, however, were exempted from this rule in 1964 because regulators believed they had sufficiently high engine safety margins to operate at greater distances from the nearest airports.

Eventually, improvements in engine reliability, demonstrated over a period of decades, convinced regulators that extended-range twin-engine operations (ETOPS) made sense and would result in a more efficient and safe global air-transportation system.

## **ETOPS History**

Original flight rules were based on the demonstrated performance of piston engines, which were far less reliable than the jet engines used today. With more moving parts, they simply were more likely to fail. But by the 1970s, advances in engine technology had yielded a 10-fold improvement. In 1983, a second generation of safe and efficient twinjets – most notably the Boeing 767 – powered by high-bypass turbofan engines entered the scene.

Discussions among members of the international aviation community resulted in new ETOPS guidelines in 1985 allowing twinjets to operate at 120 minutes away from the nearest airport. Three years later, the limit was increased to180 minutes. In 1995, the rules were again updated, allowing new airplane models and operators to fly ETOPS routes from the first day of revenue service. The Boeing 777, being the first to do so, flew routes like New York to Paris; Chicago to Frankfurt; and Washington, DC to London.

ETOPS guidelines were codified into regulations in 2007. Under these new rules, airplanes and operators are no longer bound by arbitrary flight limits but may fly at times proven for each model during flight test and certification.

In addition, safety improvements for ETOPS twin jets made such sense that regulators have now added ETOPS limits on three- and four-engine passenger models on operations more than 180 minutes away from a suitable airport. The ETOPS acronym is now more broadly defined as extended operations, without the twinjet reference.

#### Fact Finding Verifies Engine Performance

Extensive Boeing engineering research in the late 1980s revealed some unexpected facts about engines and airplane operations.

Contrary to popular thought, the company found that accident risks are not linked to flight duration. There is no greater risk of an accident on longer flights than there is on shorter ones. Findings also determined that the greatest propulsion risks involve engine disintegration and single-engine malfunction combined with crew errors, regardless of the number of engines.

Interestingly, the team found that propulsion-related accident risks *increase* with a higher number of engines. More engines do not necessarily make an airplane safer, but good design practices and thoughtful operations do.

Airplane manufacturers wanting to achieve the highest levels of ETOPS flexibility increased the redundancy within airplane system to lower diversion rates and improve safety during long diversions should one be necessary. In addition, airlines have developed more robust maintenance practices and increased the reporting of in-service events for better understanding and prompt response.

#### **Benefits for Airlines and Passengers**

Twinjets are naturally more fuel efficient, which is a huge benefit to carriers and passengers. ETOPS allows operators to economically fly routes between small cities,

permitting travelers to fly more direct, "point-to-point" routes, rather than travel in what is called a "hub and spoke" model. And that means fewer flight legs, shorter travel times, better environmental performance and less cost, particularly for fuel. Such savings are an incentive to fly ETOPS-approved airplanes.

#### **Requirements Drive Better Performance**

ETOPS regulations require manufacturers to meet clear design criteria and demonstrate the stand-alone capabilities of the engine, as well as those of the airframeengine combination. These demonstrations must be complete before ETOPS approvals are granted by authorities – in Boeing's case, the U.S. Federal Aviation Administration (FAA).

The company's ETOPS design philosophy is straightforward: all systems are designed to ensure, to the greatest extent possible, that pilots will not need to divert from their planned course. The next level of protection ensures that if a diversion is necessary, the airplane can safely support it.

This approach means engines are more reliable and system redundancy throughout the airplane is more important. For example, improvements have been made to the auxiliary power units, which can provide a back-up power source in the event of an engine failure. And fuel systems on twinjets are configured such that fuel feed to either engine on the airplane can be provided by redundant sources.

Manufacturers demonstrate ETOPS compliance through analysis, laboratory tests, engine tests and airplane flight tests. The most recent example of ETOPS demonstration – the Boeing 787 Dreamliner – illustrates the process.

### 787 ETOPS Testing and Performance

Engine ground tests included 3,000 simulated flight cycles for each engine type and included simulated systems loads as well as normal- and extreme-flight conditions. Engineers ran several scenarios, including 330-minute single engine diversion cycles, during which a single engine carries the electrical generation and thrust load for the airplane. With tests concluded, engine manufacturers performed engine tear-downs and inspections to verify the integrity of the engines.

Similarly, Boeing conducted extensive ETOPS testing during the flight test program, including numerous demonstrations of the airplane's ability to land safely on one engine, even if it meant flying in excess of 330 minutes to reach a suitable airport. Boeing engineers simulated a single-point failure involving the engines; they also increased the complexity by adding the unlikely presence of other failures and intentionally disabling other systems. Performance in extreme conditions was successfully demonstrated because multiple layers of redundancy and protections are built into the 787 design. During one test, five of the airplane's six electrical generators were disabled, leaving only one to provide the required electrical power during a 330minute diversion.

ETOPS approval isn't limited to airplane manufacturers. Carriers must also show that they have operational plans to support ETOPS, including a maintenance plan that ensures continued compliance. Among the airlines' responsibilities are ongoing tracking and reporting of engine problems, some of which require additional focus during the first 250,000 hours of operations. "Watch items" include electrical failures, fuel loss or unavailability, cabin-pressure failures, forced returns to the origin airport and diversions to alternate airports.

Resolution of such events must be approved by the FAA. After the first 250,000 hours of operations, ongoing reporting continues as problems are discovered and resolved, ensuring continuous improvements in safety and reliability. Tracking is easier with the 787 because it features increased airplane health-monitoring capabilities.

Prior to the 787, the industry's best ETOPS performer was the 777, with fewer inservice events and continued leadership in safety and reliability. But in its first 15 months of operations the 787 saw fewer reportable ETOPS events than the 777 experienced during its same initial period, and it has shown even better performance. That said, Boeing continues to improve 787 performance because it's what our customers expect and what we expect of ourselves.

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