A deep dive into ETOPS

Engines Turn or People Swim?

Early jet engines were very unreliable, so, for the safety of passengers and crew a regulation was put into place that no two-engine aircraft may fly farther than 60 minutes from a suitable alternate aerodrome. However, with the further development of jet engine technology their reliability skyrocketed, opening the possibility for longer diversion distances. The required certification for this is called ETOPS, and that's what we'll take a look at today. Brace yourselves, it's about to get technical…

Note: In this Bulletin I'll refer only to the European regulations on ETOPS, there may be slight differences in the specifics of other countries' certification or operational requirements. Where company procedures are referred to, any example given will be the procedures of my employer.

1. What is ETOPS and where did it come from

As I have outlined in the introduction, until the late 1970s twin-engine airliners were barred from flying overwater (or over other remote areas) for long stretches, which especially over the north Atlantic meant, that three- and four engine aircraft like the DC-10, MD-11, Lockheed Tristar and the Boeing 747 reigned supreme. For many thinner routes these aircraft were however not economically viable, so manufacturers together with the airlines were looking for solutions and found it in ETOPS.

Figure 1: Direct route ZRH-MIA with 60min range rings (Source: www.gcmap.com)

ETOPS is Extended-range Twin-engine Operations, and first we need to talk about terminology, since the naming conventions have changed over the years. Some regulators have kept up with the naming changes in the ICAO standards, while others have stuck to the original naming scheme, and others yet mix them wildly so it's advantageous to know all the combinations. You may hear the abbreviations ETOPS, EROPS (Extended Range Operations), EDTO (Extended Diversion Time Operations) and sometimes STOPS (Standard Operations) to refer to any non-ETOPS operation. Since EASA uses ETOPS in its relevant regulation (EASA Rules for Air Operations, Part SPA) that's the abbreviation that I will be using in this bulletin.

The reason behind the name changes was to redefine the framework to be inclusive of aircraft with more than two engines to also permit them to fly farther than their standard 120 minutes from a suitable diversion airport. This came essentially at the request of operators of the Boeing 747 and Airbus A380 wanting to further extend their flagships' route network.

2. Types of ETOPS and their requirements

No matter the name though, the principle of operations is the same for all. By certifying aircraft, crew and operator the risk of such extended overwater operations can be mitigated to a level that is acceptable to the legislator. By default, a twin engine aircraft is allowed to fly a maximum of 60 minutes, a three or four engine aircraft a maximum of 120 minutes away from a suitable diversion airport.

ETOPS then extends the maximum allowable diversion distance to a limit defined in the operator's operations specification (an integral part of the operator's Air Operator Certificate – AOC) for the aircraft in question. The allowable diversion distance is indicated by a time indicated in minutes, so for example ETOPS 240 means that the aircraft in question is certified to fly routes where the nearest suitable diversion airport is no more than 240 minutes away at an approved one engine inoperative cruising speed in still air.

As an example, for the A330 at my employer, the maximum diversion time approved is 180 minutes at a single engine cruising speed of 410 kts. As only the still air case needs to be considered, TAS and GS are equal for the purposes of ETOPS certification, thus those 3 hours of diversion time at 410 kts allow for a maximum diversion distance of 1230 Nmi.

Figure 2: The same route but with ETOPS 180 applied (Source: gcmap.com)

In order to be certified for ETOPS operation, the operator must meet numerous requirements:

- The aircraft itself needs to have an ETOPS type approval. This is part of the aircraft's type certificate, and oftentimes there will be different ETOPS ratings available as options from the manufacturer. This includes among other things proof of engine reliability, appropriate fire suppression capabilities as well as, depending on the certification method, oxygen system on board. Note that it is always the combination of airframe and powerplant that is certified, so it is possible that an A330-300 with Rolls Royce Trent 772B E2 engines has a different ETOPS rating than the same A330-300 but with Pratt and Whitney PW4168A engines. Furthermore, many of the above listed systems apart from the powerplant are often offered as options to the customer, meaning that not all A330s with Trent 772B E2 engines will have the same ETOPS certification and that they will only qualify if the operator chose to install the additional fire suppression bottles etc.
- The operator must be certified to conduct ETOPS as well, that certification usually includes things such as management structures, safety management system, operational control and flight support, continuing airworthiness and maintenance as well as the training and checking syllabi for all the personnel involved in the ETOPS operation. This certification also comes with a maximum diversion time, and the more restrictive of the two has to be applied.
- Finally, the crew also needs to be trained for and checked on ETOPS procedures. This mostly applies to flight planning requirements and contingency procedures and would normally be completed during type rating onto an ETOPS fleet, while recurrent training is usually coupled to the regular simulator trainings.

3. Flight Planning

In order to render flying at extended range safe, certain requirements must be met during the flight planning phase, including the availability of diversion aerodromes, technical status of the aircraft and fuel requirements, and we'll look at each of these individually.

3. A. ETOPS Diversion Aerodromes

To provide reasonable assurance that an aircraft is able to land at one of the planned ETOPS alternates the operator, usually flight dispatch check both before the flight and

inflight before the aircraft enters the ETOPS portion of its flight that the selected alternates meet the criteria for ETOPS operation. The following factors must be considered:

- The airport must be on the operator's Approved Aerodrome List, meaning that the operator has checked the general suitability of the airport for operation with the type you're flying (think runway and apron strength, runway and taxiway width, stand size, availability of handling equipment etc.).
- The airport must be open during the time frame where it might be needed as an ETOPS alternate, or the airport must be able to be opened within the applied diversion time, also taking into consideration any NOTAMs that might impact the airport's operations.
- The airport must have at least ICAO RFF Category[1] 4 and the required forces must be available at 30 minutes' notice maximum.
- Taking into consideration the anticipated weather and runway surface condition, the aircraft must be able to land on the runway length available, and the aircraft must be able to meet the required missed approach gradient for the expected approach.
- The weather must meet ETOPS planning minima as well as standard wind limitations during a period from the earliest expected landing time at the alternate until one hour after the last expected landing time. The planning minima are defined as the minima for the expected instrument approach incremented as follows:

Type of Approach[2]	Applicable planning minima	
	DA/H	RVR
APV Cat I **PA Cat I, II or III**	Chart minimum + 200ft	Chart minimum + 800m (0.5SM)
NPA	Chart minimum + 400ft	Chart minimum + 1500m (1SM)

Only once all these conditions are satisfied may an ETOPS alternate be planned, and the conditions must be monitored inflight too (a task usually delegated to flight dispatch or mission support) in order to be able to reroute a flight should a required ETOPS alternate no longer be available.

3. B. Fuel planning

There is a requirement that any ETOPS flight must be able to divert at any point of their route and arrive at the ETOPS alternate with 15 minutes of holding fuel at 1500ft AAL. So, if the last ETOPS alternate is very close to the destination, or if the destination itself is the last ETOPS alternate, it is possible that additional fuel is required to cover this requirement.

Three cases are considered for each critical point along the ETOPS portion of the route:

- Engine failure rendering one engine inoperative
- A loss of pressurisation requiring descent to a lower altitude
- The combination of the two

[1] An airport's RFF category indicates what size of aircraft the airport's Rescue and Firefighting services can handle based on aircraft length and fuselage width. For more information click here.

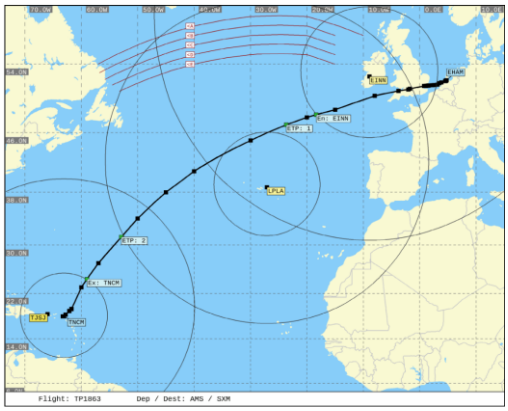
[2] APV are all approaches with vertical guidance that do not qualify as precision approaches, such as RNP approaches to LPV or LNAV/VNAV minima.

In almost all cases the last scenario (OEI Decompression) is the most critical. This is because the decompression requires you to fly at a lower altitude which burns a lot more fuel, and the windmilling engine creates drag, further increasing fuel consumption.

In any case however all scenarios must be calculated and the most restrictive must be applied. The calculation for the critical fuel scenario includes fuel to cover the use of anti-ice if icing is forecast during any portion of the diversion flight path as well as fuel for APU use if it is required as an additional source of electric power or high-pressure air.

Once the minimum diversion fuel required for the most restrictive scenario at each critical point is calculated, those get compared to the minimum fuel at that waypoint for the normal flight planning including the normal fuel reserves, and if at any point along the route the ETOPS diversion fuel required would be more than the regular fuel required, additional fuel to make up the difference must be carried.

As this is all very theoretical, let's look at an example. We are flying KLM775 from Amsterdam (EHAM) to Sint Maarten (TNCM). Our route is planned with ETOPS alternates Shannon (EINN), Lajes (LPLA) and Sint Maarten (TNCM) at ETOPS 180 with a diversion speed of 410kts. Simbrief kindly calculated our flightplan for us, planning with destination alternate San Juan (TJSJ).



PLANNED FUEL

FUEL	ARPT	FUEL	TIME
TRIP	SXM	75866	0946
CONT 3%	BDA	2276	0018
ALTN	SJU	5283	0046
FINRES		3001	0030
ETOPS/ETP		1415	0011
MINIMUM T/OFF FUEL		87841	1131
EXTRA		0	0000
T/OFF FUEL		87841	1131
TAXI	AMS	381	0012
BLOCK FUEL	AMS	88222	
PIC EXTRA		.....	
TOTAL FUEL		.....	
REASON FOR PIC EXTRA		.....	

FMC INFO:
FINRES+ALTN 8284
TRIP+TAXI 76247

Figure 3: Example routing and planned fuel figures (Source: simbrief.com)

The most critical scenario is an OEI decompression at ETP 2 (between LPLA and TNCM). Without planning ETOPS fuel, we would need 26.5t remaining fuel there, covering for a remaining trip fuel to TNCM of 18.2t, fuel to divert to TJSJ of 5.3t and a 30min final reserve of 3t. If we were however to have an engine failure and a depressurization at that exact point, we would need 26.2t of fuel to reach either TNCM or LPLA, and then 1.7t to cover the 15 minutes of holding at 1500ft AAL. The total required fuel at ETP 2 is thus 27.9t and an ETOPS additional fuel of 1.4t is planned by simbrief, covering the exact difference between the two values.

3. C. Aircraft technical status

It would seem obvious that an aircraft must always be in perfect shape to be allowed to fly, however minor defects are allowable for daily operations until they can be fixed. All the parts that can be inoperative or partially operative are listed in the so-called MEL (Minimum Equipment List), and structural components that may be defective (such as aerodynamic fairings etc.) are listed in the CDL (Configuration Deviation List). Any item not listed in those two documents must be working for flight.

Before each flight the technical log of the aircraft must be checked and the impact on operations evaluated using the MEL and CDL. These documents can contain additional instructions for operations, for example a missing boat tail to a flap track fairing may have a CDL entry requiring dispatch to increase the fuel flow for all segments by 1.6%, or a generator inoperative may have a MEL entry requiring the APU to be run for the entire flight increasing fuel burn by 65kg/h, or, relevant for our discussion here, one channel of the automatic cabin pressure controller may be inoperative, but no ETOPS flying is permitted with that defect.

So, before any ETOPS flight the crew needs to ascertain that the aircraft is allowed to be operated under MEL also for ETOPS, and that any additional fuel requirements coming from the technical status are taken into account, also for the ETOPS fuel planning.

4. Inflight procedures

During normal operations there isn't much in terms of additional procedures you need to comply with, only that before ETOPS entry you need to re-evaluate the weather forecast at the ETOPS alternates, re-check the airplane technical status and ensure you have sufficient fuel to cover the requirements I explained in the fuel planning part.

Your OFP would have information on the so-called Equi-Time-Points (ETP) between your diversion aerodromes. At those points, considering the forecast winds and assuming the one-engine inoperative cruise speed, it would take you the same amount of time to divert to the two nearest ETOPS alternates. In the above map you could see them marked as "ETP: 1" for the ETP between Shannon and Lajes and "ETP: 2" for the ETP between Lajes and Sint Maarten. Usually, these points will be inserted into the FMS, either into the route itself using an along-track waypoint or using the fix page drawing a circle around the fix before the ETP with a radius corresponding to the distance between the fix and the ETP. You can find out how to enter these points into your specific FMS by consulting the manual for your aircraft.

For contingency procedures during ETOPS aircraft specific instructions apply, however additionally you need to keep in mind the impact the encountered contingency has on the continuation of your flight, for example whether a safe approach and landing is still possible at ETOPS alternates.

Chiara Paganini

First Officer A220

Guest Author, Pilot Training Department