fachhochschule hamburg
FACHBEREICH FAHRZEUGTECHNIK
Studiengang Flugzeugbau

Berliner Tor 5
D – 20099 Hamburg

Fahrzeugtechnik

theoretische Arbeit
- Flugzeugbau -

Extended Range Operations with Two-Engined Aeroplanes

Verfasser: Stefan Ebel

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Prüfer: Prof. Dr.-Ing. Dieter Scholz, MSME

Preface

The following ETOPS report is the result of the investigation about regulations to serve routes with twin-engined aircraft`s. These limitations are given from the authorities especially the FAA and JAA to the manufacture and airliner.

Until today there is no comprehensive information about the ETOPS theme existing, so I started collecting different material all about ETOPS. It was very helpful to have access to DaimlerChrysler Aerospace Airbus and AIRBUS INDUSTRIE documents. All these chapters are close to the presentation [1] [2] of the *AIRBUS INDUSTRIE – First ETOPS Conference in February 1994.*

The complete ETOPS history from the beginning of aviation with piston twin-engined aircrafts to the high bypass engines on modern Airbus and Boeing aircrafts is explained. The ETOPS regulations are still in a process of adaptation to new technical standards, this reading will consider the standards until 1995.

Stefan Ebel, Hamburg February 1999

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Abbreviations

A/C	Aircraft
AC	Advisory Circular
AC	alternating current
AMJ	Advisory Material Joint
APU	Auxilary Power Unit
CDL	Configuration Deviation List
CMP	Configuration, Maintenance and Procedure Standards
CMP	Configuration, Maintenance and Performance Standards
CP	Critical Point
EEP	ETOPS Entry Point
ECAM	Electronic Centralized Aircraft Monitoring
en-route	diversion time
ETA	Estimated Time of Arrival
ETD	estimated time of departure
ETOPS	Extended Twin engine Operations
ETP	Equitime Point
FAA	Federal Aviation Administration
FADEC	Fully Authority Digital Engine Control
FAR	Federal Aviation Regulations
FCOM	Flight Crew Operating Manuel
FOB	Fuel On Board
ICAO	International Civil Aviation Organization
IFSD	In Flight Shut Down
JAA	Joint Aviation Authorities
MCT	Maximum Continuous Thrust
MEL	Minimum Equipment List
MMEL	Master Minimum Equipment List
MNPS	Minimum Navigation Performance Specification
MPS	Minimum Performance Specification
NAT	North Atlantic
nm	nautical miles
NPA	Notice of Proposed Amendment
RAT	Ram Air Turbine
TAS	True Air Speed
TOW	take off weight

1 Introduction

1.1 The meaning of ETOPS

ETOPS (Extended Twin Operations) is the acronym created by ICAO (International Civil Aviation Organizations) to describe the operation of twin-engined aircraft over a route that contains a point further than one hour's flying time, at the approved one-engine inoperative cruise speed (under standard conditions and still air), from an adequate airport.

ETOPS regulations are applicable to route over water as well as remote land areas. The development of modern twinjet aircraft has required the rewriting of one of the chapters in aviation to accommodate the unique capabilities of these special aircraft. The old rules were not appropriate for modern twin-engined aircraft because they were based on the performance and safety features of aircraft from a much earlier technology, which were much less capable and reliable.

The civil aviation regulatory authorities have responded favorably to these technological and safety advances and have worked with the industry to create a new set of rules. These new rules take advantage of the unique efficiency, performance and safety features of today's twinjets. These rules also permit operators to manage their resources in a more effective and efficient way.

The purpose of ETOPS is very clear. It is to provide very high levels of safety while facilitating the use of twinjets on routes which were previously restricted to three- and four-engined aircraft. ETOPS also permit more effective use of an airline's resources.

1.2 Historical background

There is a extensive history in the evolution of the rules which are the foundation of ETOPS operations. Such an operation is not as recent as one would think, the first one taking place in 1919 when two Britons, Captain John Alcock and Lieutenant Arthur Whitten Brown crossed the Atlantic in a twin-engined Vickers Vimy, eventually landing in an Irish peat bog after a sixteen-hour flight.

1.2.1 Original regulations

As early as 1936, the FAA created the requirements that are incorporated in principle in FAA section 121.161 today. The initial rule applied to all types of aircraft regardless of the number of engines. All operations were restricted to an en-route area of operation that was within 100 miles of an adequate airport. In those days 100 miles was about 60 minute of flying time in many aircraft if an engine was inoperative.

The initial FAA "60-minute rule" was established in 1953. This rule focused on engine reliability of piston powerplants that were available during the late 1940s and early 1950s. In general, twin-engined aircraft were restricted to areas of operation defined by 60 minutes at the one engine inoperative cruise speed (under standard conditions and in still air) from an adequate airport. However, the rule was flexible. It permitted operations beyond 60 minutes if special approval was obtained from the administrator.

This special approval was based on the aircraft to be used. There was no regulatory upper limit for this special approval.

The purpose of these rules was to restrict flying time to an alternate airport, and hence reduce the risk of a catastrophe by lowering, to an acceptable level, the probability that all engines would fail. In other words, the lower level of reliability in piston powerplants required that aircraft remain within 60 minutes of an adequate airport to ensure that, if one engine failed at any point along the route, a landing could be made before the remaining engine failed.

The ICAO Standing Committee on aircraft performance reviewed piston engine failure data during 1953.

Also in 1950s, ICAO published recommendations stating that 90 minutes (two-engine speed) diversion time was acceptable for all twin-engined aircraft. The more flexible ICAO recommendations as adopted by many non-US regulatory authorities and many non-US airlines started to operate their twins under this rule.

1.2.2 First generation of turbine engine reliability

The introduction of the jet engine into civil aircraft led to significant improvements in powerplant reliability compared to piston powerplants. The introduction of the Pratt & Whitney JT8D turbojet powered aircraft led to a major advance in propulsion system reliability and safety that permitted the development of twin-engined aircraft that were bigger and faster than four-engined piston aircraft.

Operation experience with the JT8D and others over the last 25 years has demonstrated that very high levels of reliability can be achieved with jet engines.

Statistics show that jet engines are much more reliable than piston engines, and propulsion-related accidents have been reduced significantly when compared to piston-powered aircraft.

1.2.3 High-bypass engines and widebody twin aircraft development

By the early 1980s, great advances had been made in the aircraft operational environment, design reliability and integrity. These advances were based on the highly satisfactory JT8D experience and the knowledge gained from the operational introduction of the Pratt & Whitney JT9D, the General Electric CF6, and the Rolls-Royce RB211 large high-bypass engines.

Widebody twinjets had been in service for some time (A300 was the first in 1974, A310 in 1983) and operators could see the advantage of utilizing their twinjets in applying ICAO rules on routes where, by the old rules, they were forced to use three- and four-engined aircraft. Also, contrary to the experience with piston engines, jet engine power and size did not appear to have any discernible impact on failure rate. The failure rates of some of the large high-bypass engines were almost as good as the JT8D and were nearly ten times better than piston engines.

The greatest initial interest in 120-minute rules ETOPS operation was over the North Atlantic (NAT). The highly competitive nature of NAT operations made the use of widebody twinjets very attractive. However, operations under the 60-minute rule required indirect routings (usually referred to as random routes) and the use of en-route alternate airports which have limited airport services and facilities and are subject to frequent weather limitations. NAT operations under 120-minute rule, however, would permit operators to use the minimum cost routings (Organized Tracks System) and enable the use of alternates that were properly equipped to support an aircraft that was diverting.

All of this slowly led the authorities and the industry to the realization that advancements in airframe, avionics, and propulsion system technology had created the need and the opportunity to create a new kind of operation. All twinjets could now be designed with performance and safety improvements that permitted them to safely conduct operations that had been historically restricted to three- and four-engined aircraft. The advantage of the A300-600, A310, 757, 767, MD-90, A320, A321, and A330 and a new generation of high-bypass engines provided twinjets with the efficiency, safety, and range/payload capabilities which made the old 60-minute rule restriction inappropriate.

In the early 1980s, ICAO formed an ETOPS Study Group to examine the feasibility of extended-range operations with these new twinjets and to define the special criteria that should be met to ensure that these operations were conducted with a very high level of safety. At the same time, the FAA had begun the initial work that resulted in Advisory Circular (AC) 120-42 which is the US criteria for ETOPS. The ICAO Study Group recommended that a new ICAO rule be established to recognize the capabilities of these new aircraft and the limitations of the older aircraft.

The end result was amendment to ICAO Annex 6, unless the aircraft could meet special ETOPS safety criteria, recommended that all turbine-powered aircraft be restricted to 60 minutes, at single-engine speed, from an adequate airport.

1.2.4 Initial 120-minute ETOPS operations

Although a limited number of extended-range operations had been conducted under the old ICAO guidelines, ETOPS as we know it today began in the mid 1980s. In 1985, the FAA issued AC 120-42 which established criteria for approval of a deviation in accordance with FAR 121.161 to increase the ETOPS area of operation to 120 minutes at the single-engine cruise speed under standard conditions in still air. This AC also permitted areas of operation as great as 138 minutes if additional special criteria were met. Several other civil aviation authorities also issued ETOPS criteria including CAA UK, DGAC France, DOT Canada and DOT Australia during the same time period. Many other countries relied on the guidance provided in the ETOPS amendments to ICAO Annex 6.

In 1993, the European Joint Airworthiness Authorities (JAA) developed their own criteria (AMJ 120-42, Advisory Material Joint) which combines the best points from the individual European rules and the FAA criteria. A summary of the historical evolution for the ETOPS regulations is given in table 1.

Table 1 Evolution of ETOPS regulation

Year	*Action*
1919	Captain John Alcock and Lieutenant Arthur Whitten Brown crossed the Atlantic in a twin-engined Vickers Vimy
1936	the FAA created the requirements that are incorporated in principle in FAA section 121.161 today
1953	twin-engined aircraft were restricted to areas of operation defined by 60 minutes at the one engine inoperative cruise speed
1980	ICAO formed an ETOPS Study Group to examine the feasibility of extended-range operations with these new twinjets FAA had begun the initial work that resulted in Advisory Circular (AC) 120-42 which is the US criteria for ETOPS
1985	the FAA issued AC 120-42 which established criteria for approval of a deviation in accordance with FAR 121.161 to increase the ETOPS area of operation to 120 minutes. This AC also permitted areas of operation as great as 138 minutes if additional special criteria were met
1988	The FAA issued AC 120-42 A, which provided the criteria for 75-minute, 120-minute, and 180-minute operations
1989	FAA approved the first 180-minute ETOPS operation. ETOPS operations are now becoming commonplace on the North Atlantic routes where actually more twins than trijets or quads are flying.
1993	JAA developed their own criteria (AMJ 120-42, Advisory Material Joint) which combines the best points from the individual European rules and the FAA criteria

1.2.5 Modification of existing aircraft

Although there were several aircraft that could meet the proposed ETOPS performance requirements and had the range/payload capabilities to make ETOPS operations economically feasible, there were no aircraft capable of meeting the aircraft system and propulsion systems requirements at the time that the ETOPS rules were being developed. Therefore the first ETOPS aircraft were modified versions of aircraft originally intended for pre-ETOPS service. These modifications were necessary to improve primarily the reliability of the propulsion systems and to enhance the redundancy and performance of electrical, hydraulic and avionik systems. A hydraulically driven electrical generator was added to most of these Aircraft to provide four independent sources of AC electrical power to ensure that power to all critical systems would always be maintained without a time limitation.

The very good experience overall with 120-minute ETOPS led the authorities and the industry to consider the possibility of 180-minute ETOPS operations. The potential for 180-minute ETOPS operation was very important to operators because it meant that almost any route in the world could be economically serviced by twinjets. In addition to major design enhancements incorporated in ETOPS aircraft, improvements in high-bypass engine reliability made 180-minute operations possible.

The FAA issued AC 120-42 A on December 30, 1988, which provided the criteria for 75-minute, 120-minute, and 180-minute operations. On January 18, 1989, FAA approved the first 180-minute ETOPS operation. ETOPS operations are now becoming commonplace on the North Atlantic routes where actually more twins than trijets or quads are flying.

1.2.5.1 Development of modern ETOPS aircraft

The very successful experience during the introduction of ETOPS, the safety benefits associated with these designs, and the large economic benefits provided to ETOPS operators have had a powerful effect on the design of all modern twinjets. Because of the success of ETOPS, it is now economically feasible to build very large twinjets. These new aircraft (A330, B777) will have even better safety features and higher operating efficiencies.

The effect ETOPS has had on high-bypass engine reliability is especially impressive. Today, the engines used in ETOPS are as much as ten times more reliable (MTBUR Mean Time Between Unscheduled Removal) than high-bypass engines were ten years ago. More significantly, the engines on new ETOPS aircraft, such as the A330, should be even more reliable due to design improvements that are based on current ETOPS experience.

1.2.5.2 Airbus ETOPS milestones

Airbus operators have been operating their A300 twinjet aircraft across the North Atlantic, the Bay of Bengal and the Indian Ocean under the 90-minute ICAO rule since 1976. However, ETOPS officially began in 1985 with the newly issued ETOPS criteria.

In 1985, the first ETOPS operation (90 minutes) were made in February by TWA with a 767 and in June by Singapore Airlines with an A310.

In April 1986, PanAm was the first to inaugurate transatlantic revenue service with A310-200 and A310-300 aircraft. In less than five years, more than 20 operators joined the two pioneers in Airbus ETOPS operations. For the year 1992, the ETOPS flights represented more than 30% of the revenue hours of the A310 world fleet (it represented 6% in 1986). At that time, around 60% of the A310 world fleet operators had flown ETOPS routes.

In March 1990, the A310-324 (PW4000) was the first FADEC (Fully Authority Digital Engine Control) engine powered aircraft to receive ETOPS approval by the FAA. At the same time, the A300B4-605R was the first aircraft to get ETOPS approval for 180 minutes diversion time.

By the end of 1991, all A310 and A300-600 were approved for 180 minutes diversion time by the French DGAC.

In September 1991, the A320 was the first fly-by-wire aircraft to be approved for ETOPS operations.

In April 1994, the A330-301 (CF6-80E1A2 engines) has obtained the ETOPS Type Design Approval from the JAA with 120-minute diversion time. In May 1994, Aer Lingus was the first operator to inaugurate ETOPS operations over the North Atlantic with this model.

In the same time, the A300-600 with CF6-80C2A5F engines (featuring FADEC) has obtained the full ETOPS Type Design Approval (180-minute diversion time) from JAA.

In November 1994, the A330-321/A330-322 (PW4164/PW4168 respectively) has obtained the ETOPS Type Design Approval from the JAA with 90-minute diversion time at entry into service. The first operators were Thai Airways, Malaysian Airlines and LTU.
In January 1995, the A330-341/A330-342 (Rolls-Royce trent 768/trent 772 respectively) has obtained the ETOPS type Design Approval from the JAA with 90.minute diversion time to entry into service.

1.3 The benefit of ETOPS

The advent of the ETOPS regulations permitted an enlarged area of operation for the twin-engined aircraft. This area of operations has been enlarged in steps by allowance of maximum diversion time to an adequate airport from the nominal 60 minutes up to the current 180 minutes.

The maps in Fig. 1 have been established independently of aircraft type at a typical single-engine true airspeed of 400kt.

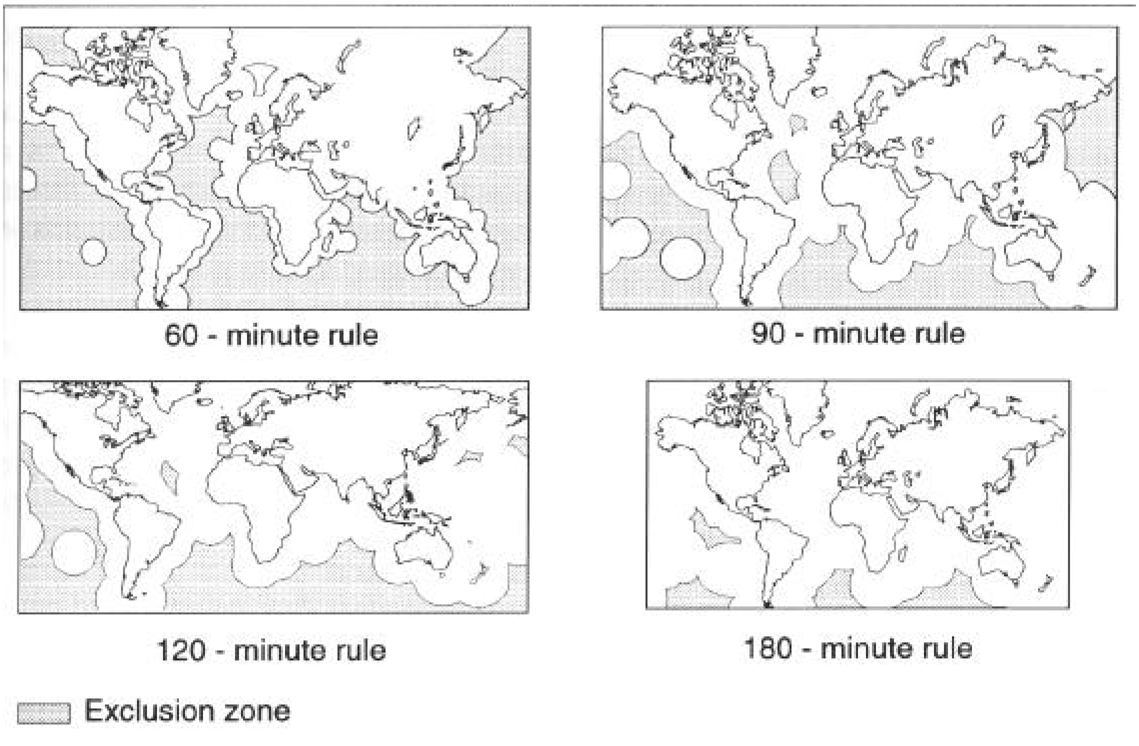

Fig. 1 World exclusion zones for 60-, 90-, 120-, 180-minute rules [2]

The efficiency of direct ETOPS Routing can be demonstrated by a comparison of distance, time and fuel savings. A good example is the New York to London route Fig. 2 which is now feasible in direct track with 120-minute rules.

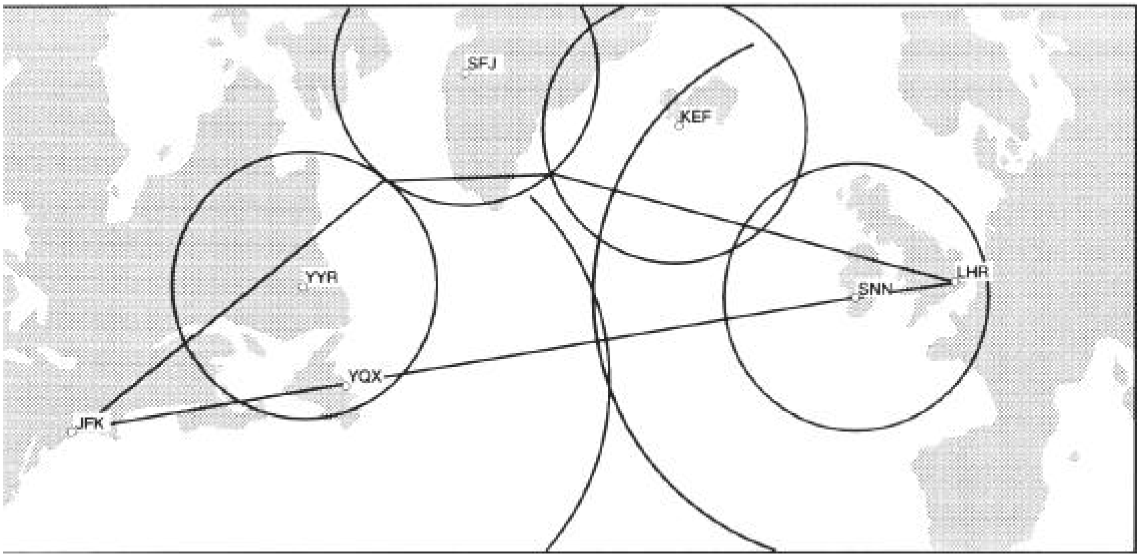

Fig. 2 New York to London track [2]

Compared to the non-ETOPS 60-minute case, the operator can save up to 2.4 tons of fuel with an A310-300 or make an equivalent payload gain. In addition to elimination of dog-leg tracking (use of the Organized Track System instead of random of en-routes), efficiency can also be improved by a reduction of the number of en-route alternates required. Thus, New York to London twin operations become practically independent of airfields in Iceland and Greenland.

A second benefit to operators is that ETOPS permits twins to be used on routes previously denied them. For example, a track from Nairobi to Singapore Fig. 3 is not possible with a 60-minute diversion time as there are not sufficient diversion airfields available. However, the increase of the diversion time to 120-minutes easily permits an operator to flexibility to use twins on this route which would otherwise remain the sole preserve of larger three- and four engined aircraft.

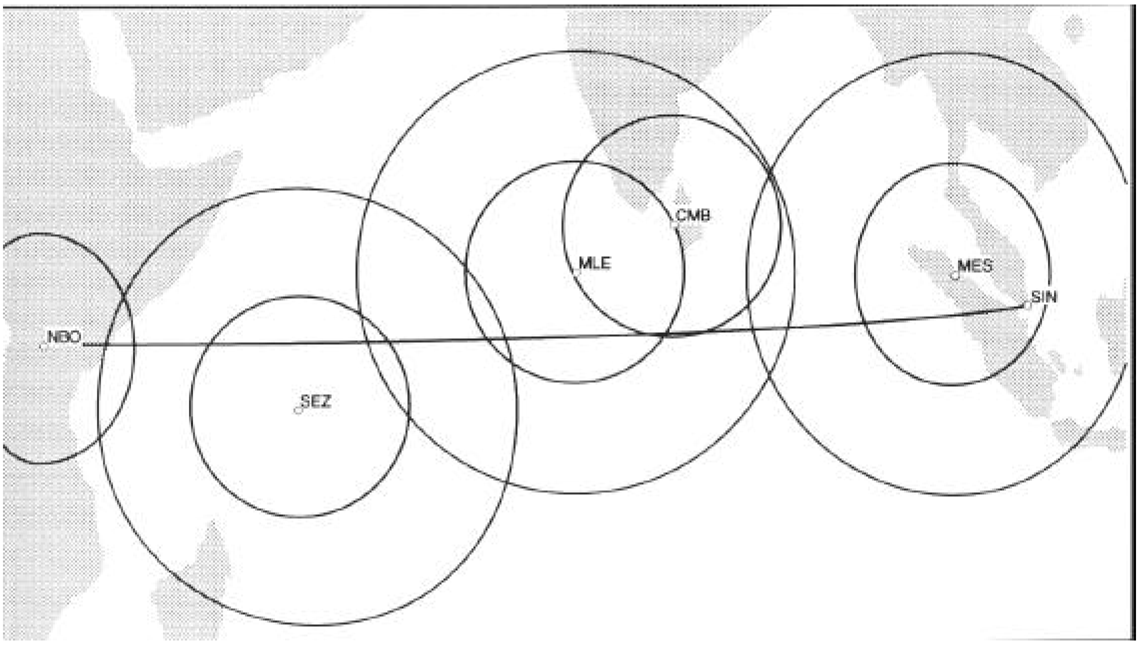

Fig. 3 Nairobi-Singapore route, possible only with 120 minutes ETOPS [2]

Moreover, the passengers also benefit from ETOPS operations with the opening of new routes between city pairs where the traffic is too thin for an economically viable operation with larger aircraft but can be supported by a smaller twin. ETOPS operations also permit flights frequencies to be increased on high-density routes such as North Atlantic routs by using smaller twins. In addition, airlines can have greater flexibility with ETOPS Aircraft which can be economical on short- as well as long-haul routes.

2 The regulations, what does it mean to ETOPS

2.1 The Intention of the ETOPS Requirements

ETOPS requirements are essentially the same for all the airworthiness authorities and are detailed in Table 2.

Table 2 ETOPS Requirements for different airworthiness authorities

FAA	issued Advisory Circular (AC) 120-42A which provides the criteria for 75-, 120- and 180-minute operations
JAA	Advisory Material Joint (AMJ) 120-42 which provides the criteria for 75-, 90-, 120- and 180-minute operations and provisions for accelerated approval for 75-, 120- and 180-minute operations (currently published as Information Leaflet (IL) number 20)
DOT Canada	issued Technical Publication (TP) 6327 which authorizes ETOPS up to 180-minute operations
CAA (United Kingdom)	issued the Civil Aviation Publication (CAP) 513 (in JAA)
DGAC (France)	issued Condition Technique Complémentaire CTC 20 (Complementary Technical Condition) (in JAA)
ACAA (Australia)	issued Air Navigation Orders
ICAO Annex 6	many other countries rely on the guidance provide in the ETOPS amendment of the International Civil Aviation Organization

The benefits of ETOPS are clear. Airliner recognize it by choosing to operate ETOPS and aircraft manufacturers perceive this by designing ETOPS-capable aircraft. However, it is also clear that ETOPS operations must be regulated in order to ensure that twin-engined aircraft operating under ETOPS are at least as reliable and safe as existing three- or four-engined aircraft.

To achieve this expected level of reliability and safety, the airworthiness authorities control the certification of the "Aircraft ETOPS Type Design Approval" as well as granting "ETOPS Operational Approval" to airlines. Moreover, the aircraft ETOPS Type Design Approval and Operational Approval, although not renewable, is continually reviewed and may be withdrawn.

Aircraft ETOPS Type Design Approval

Before an airline can even contemplate operating an aircraft under ETOPS conditions, the aircraft must first have either been designed or modified and approved to meet the more stringent ETOPS certification requirements.
It is therefore the responsibility of the aircraft manufacturer to ensure that the aircraft's design satisfies the ETOPS regulations.

To meet all these requirements, it is convenient to split the aircraft ETOPS Type Design Approval into two parts:

- ETOPS type design eligibility
- ETOPS type design capability

The former concerns the ETOPS design features envisaged prior to inservice experience and the latter concerns reliability improvements considered after such experience.

ETOPS type design eligibility

The aircraft designer must first demonstrate that its aircraft complies with the required ETOPS design criteria and is therefore eligible for ETOPS.

Design assessment

The aircraft's design must conform to the valid ETOPS regulations notified by the certificating authorities at the time of the Type Design Approval. Any changes required to the aircraft's basic design are contained in the Airbus Industrie "Configuration, Maintenance and Procedure Standards" (CMP) document. This document is an authority-approved document and is regularly updated.

The following design considerations must be introduced:

Propulsion system reliability

Propulsion system reliability is the most vital aspect of ETOPS and must be sufficient to ensure that the probability of a double engine failure from independent causes is lower than defined limits (this requirement establishes a maximum In-Flight Shutdown (IFSD) rate of 0.02/1000 engine hours for 180-minute ETOPS).

Electrical power sources redundancy

A sufficient number of reliable, independent and non-time-limited electrical power sources (at least three) must be available to ensure that basic aircraft functions including Communication, navigation and basic flight instrument (such as altitude, airspeed, attitude and heading) remain available.

Engines and APU electrical generators must provide full technical electrical power availability throughout the normal flight envelope. Every Airbus ETOPS aircraft is equipped with an emergency/standby generator which gives a total of four independent generators. The design intent is to obtain dispatch flexibility when conducting an ETOPS mission.

APU design

APU must be designed to have airstart capability throughout the normal flight envelope and cold start capability at all certified operating temperatures within flight duration limitations.

Emergency/standby electrical generator design

In the event of any single failure or combination of failures, electrical power is still provided for essential equipments. All information provided to the flight crew remains sufficiently accurate for the intended operation.

Minimum crew workload

In the event of a single failure or any combination of system failures, indications of residual system capabilities should be such that the flight crew have the necessary information to make decisions or diversions at any point on the route. Crew workload should be kept to an acceptable level.
To achieve the required system redundancy, Airbus Industrie has paid particular attention to the supply of sufficient emergency/standby electrical power for emergency services following the loss of engine and APU generators.

System redundancy

During single-engine operations, the remaining electrical, hydraulic and pneumatic power should continue to be available at levels necessary for safe flight and landing.

For example, on A310 and A300-600 the system redundancy is as table 3:

Table 3 A310 and A300-600 system redundancy

Systems	Normal	One engine shutdown	Remark
Hydraulic	3 systems (1) 1 RAT back-up	3 systems (1) 1 RAT back-up	(1) one affected system can be restored by power transfer unit (PTU) or electropump
Electrical	4 generators: - engines - 1 APU - 1 standby (4) Batteries	3 generators: 1 engine (2) 1 APU (3) 1 standby (4) Batteries	(2) Full electrical capability (3) APU operation restores redundancy and independence of electrical generation (4) ETOPS modification for A310-200/A300-600
Pneumatic	3 air bleed sources - engines - 1 APU	2 air bleed sources - 1 engine - 1 APU	Any air bleed sources has cabin pressurization and wing anti-ice capability.

Ice protection

Airframe and powerplant ice protection should provide adequate capability for the intended operation (taking into account prolonged exposure at lower altitude during engine-out diversion).

Safety assessment

The system safety assessment must take into consideration the extended average flight duration and maximum diversion time allowed for ETOPS.

ETOPS type design capability

After the manufacturer has demonstrated that this aircraft design is "eligible" for ETOPS, it must then show that the aircraft/engine combination has attained a sufficient reliability level based on in-service experience. Generally, the authorities require in the order of 100,000 to 250,000 engine flying hours of experience in order to obtain statistically viable reliability analysis.
However, this experience can be substantially reduced by a procedure known as "Technical Transfer Analysis" which allows credit to be awarded for development work and experience already gained on similar systems and engines. Such a procedure has been extremely useful for Airbus Industrie whose aircraft have a high degree of commonality between their systems and engines.

JAA policy statement

JAA has issued in June 1993 a policy statement regarding ETOPS Type Design Approval at entry into service (also referred to as "early ETOPS"), in which it is mentioned that:

- 180-minute ETOPS Approval will not be available without some in-service experience being gained on the airframe/powerplant combination,
- 120-minute ETOPS Approval is considered feasible at the introduction to service of an airframe/powerplant combination, so long as the authority is totally satisfied that all aspects of the Approval Plan have been completed,
- any deficiency in compliance with the Approval Plan can result in some lesser level of approval from that sought,
- operators and manufacturers will be required to respond to any incident or occurrence in the most expeditious manner. A serious single event or series of related events could result in the immediate revocation of ETOPS approval. Any isolated problem not justifying immediate withdrawal of approval will have to be under control within specified timeframe,
- progress to 180-minute ETOPS Approval will be possible for a particular airframe/powerplant combination, subject to the application of any required corrective action, after the accumulation of the following in-service experience:

  20 000 engine hours for derivative technology powerplants,
  50 000 engine hours for new technology powerplants.

In consequence, for the A330 program, Airbus Industrie has set up a "30-day reaction time process", as required by the airworthiness authorities.

The process is aimed at identifying, reporting and analyzing any ETOPS significant service event and defining an appropriate corrective action plan within 30 days if the event affects a system or component which has not yet accumulated sufficient service experience to use a statistical analysis in the assessment. This process may result in temporary revisions of the CMP as necessary to implement control measures.

2.1.1 The A330 ETOPS Design Concept

When ETOPS regulations were first formulated, the manufacturers were required to make small but significant systems design modifications to meet the new requirements. These changes included the provision of a fourth independent source of electrical power, additional cargo fire suppression equipment, and better APU reliability. These modifications are now available as standards and have been further enhanced to meet the most stringent possible anticipated design policies envisaged from the authorities.

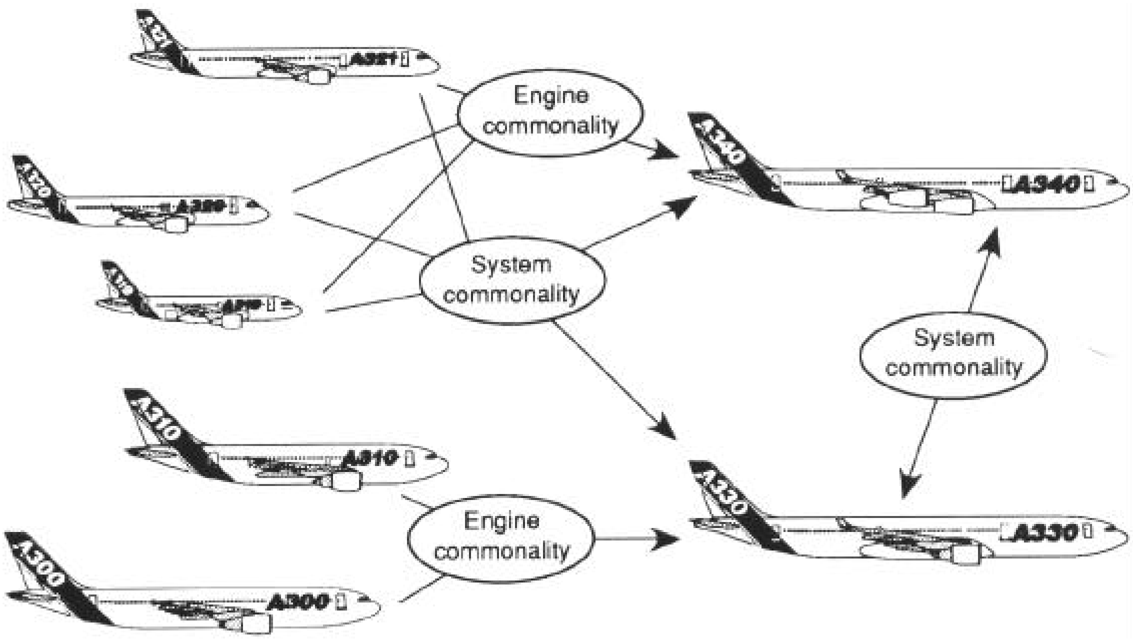

Fig. 4 Airbus Family [2]

Of crucial significance is that the A330's sister ship, the four-engined A340, incorporates virtually identical systems. This means that systems experience from the A340, which entered into service one year before the A330, is directly relevant. As we have already seen, the concept Fig. 4 is not new, Credit for system experience has been used to help achieve ETOPS approval of various aircraft, such as the 767 using 747 nacelles experience as well as taking benefit from A310 systems.

In the case of the A330, however, never before has an ETOPS aircraft been designed so closely to another model – the A340. Indeed, it was anticipated that 100% systems read-across would be achieved between the two aircraft. The A330 design commonality is not only with A340, but electrical and hydraulic systems on the A330 are conceptually similar to those already flying for many years on the A300-600 and A310. Also, A320 experience feeds through to the A330 in terms of flight control systems, and electronics bay cooling.

in addition to the wealth of relevant experience available within the Airbus product range, there is always the additional safeguard of allowing a bedding-down period of the A330 in revenue service before granting the ETOPS Type Design Approval. The confidence That the A330 can achieve early ETOPS was based on sound engineering principles.

Airbus Industrie believes the step-by-step approach to ETOPS is the most prudent path to follow. In practical terms:

- The A330-301 (GE engines) has obtained the ETOPS Type Design Approval with 120-minute diversion time and was found eligible for 180-minute ETOPS before entry into service, followed by the 180-minute approval after the build-up of sufficient fleet-wide engine hours.
- the A330-321/322 (PW engines) has obtained the ETOPS Type Design Approval with 90-minute diversion time and was found eligible for 180-minute ETOPS before entry into service. Following couple of months of operation, the 120-minute approval has been obtained, pending the further 180-minute approval.
- the A330-341/342 (RR engines) has obtained in January 1995 the ETOPS Type Design Approval with 90-minute diversion time as well as the eligibility for 180-minute ETOPS prior entry into service.

The Airbus philosophy has been endorsed by the airworthiness authorities and the early ETOPS approach of the JAA will include additional requirements at the suggestion of Airbus. These include a strengthening of systems design (more services on the standby generator, such as landing lights and windshield de-icing), and a single-engine ceiling of 22.000ft (giving the A330 the same on-engine performance as a four-engined aircraft with one engine failed).

2.1.2 ETOPS Capability Statement

Once the airworthiness authorities have agreed that the candidate aircraft/engine combination meets the requirements of the applicable regulations, the authorities declare this aircraft type capable of flying ETOPS for a given maximum diversion time.

The ETOPS capability of the aircraft becomes official, and is declared in the following documents approved y the airworthiness authorities:

- Aircraft Flight Manual (AFM)
- Standards for Extended-Range Operations (AI/EA X000; Airbus Industrie specific instruction), Configuration, Maintenance and Procedures Standards (CMP),
- Type Certification Data Sheet (TCDS),
- Master Minimum Equipment List (MMEL).

3 To obtain the operational approval

3.1 Getting the ETOPS Operational Approval

The first consideration for a potential ETOPS operator is to ensure that the candidate aircraft has received an ETOPS Type Design Approval.

The second step is to get ETOPS Operational Approval from its national operational authority to operate ETOPS.

To obtain this approval, the airline must demonstrate its competence to its authority. In other words, the airline has to prove that it has the appropriate experience with the airframe/engine combination under consideration and that it is familiar with the intended area of ETOPS operation.

Although the Operational Approval rules are documented, each operational authority may choose the "means of compliance" (European uniform) stating the exact method that an airline may use to show its readiness.

It is worth nothing that the wording "Operational Approval" doesn't refer only to the approval of the airline's flight operations organization and procedures but, more broadly, to all of the following aspects : aircraft configuration, maintenance practices, ETOPS training and dispatch practices.

To get approval for 120-minute diversion time, the regulations require that the candidate airline accumulates 12 months of consecutive in-service experience with the candidate airframe/engine combination, or less if the airline can successfully demonstrate its "ability and competence to achieve the necessary level of reliability" required for ETOPS operations. The latter approach, termed "Accelerated ETOPS Approval", is readily accepted by all authorities and they have recently published guidelines to the effect.

The accelerated ETOPS approval concept is based on a structured program of compensating factors and a step-by-step approach which is explained further. This is the same philosophy as the Technical Transfer Analysis used to accelerate the aircraft ETOPS Type Design Approval.

Once the criteria for the operational approval are met, the operator should submit to its national operational authority an ETOPS Operational Approval application, specifying its intended routes and supported by the relevant substantiating data. In response, the authority will grant a maximum diversion time, permitting the airline to start ETOPS operation.

3.2 Accelerated ETOPS Approval

The accelerated ETOPS concept has been established to allow airlines to get ETOPS approval quicker than the regulations previously permitted. The new process is based on a structured program of compensating factors. It is agreed by both JAA and FAA.

This concept represents a major change from the previous approval concept which was primarily based on a review of the operator's direct experience with the candidate aircraft. However, the means to obtain Operational Approval with reduced in-service experience does not imply that a reduction of existing reliability standards will be tolerated but rather acknowledges the fact that an operator may be able to satisfy the existing standards specified in the current regulations by demonstrating its capability in less than 12 months of operation. The configuration standards required for 120-minute ETOPS approval are considered the minimum acceptable standards for any Operational Approval, including lower diversion times, 75- or 90-minute approvals.

3.2.1 Requirements

The operator should submit an "Accelerated ETOPS" Operational Approval plan to its national authority. This plan, which is in addition to the normally required ETOPS Operational Approval plan, fully defines the operator's proposal for accelerated ETOPS and the factors which it is claiming as compensating for the normally required in-service experience.

Factors which may be considered include:

- the record of the airframe/engine combination, if it is better than the reliability objectives of the regulations and, in particular, if it is well established that there were no cases of ETOPS events linked with maintenance errors or crew errors
- The operator's maintenance and operational experience:
  - as a pervious ETOPS operator
  - as previous long-range operator,
  - with similar technology aircraft,
  - with other aircraft made by the same manufacturer,
  - with similar technology engines,
  - with other engines made by the same manufacturer.
- the support to be given by airframe, engine and APU manufacturers after start-up of operations,
- maintenance or operational support from established ETOPS operators, ETOPS maintenance organizations or vendors of computerized flight planning and operational services.
- the experience gained by the flight crews, maintenance personal and dispatch staff whilst working with other ETOPS-approved operators.

In addition, to support the above –mentioned factors, the operator should establish the appropriated procedures including:

- simulated ETOPS operation on applicant or other aircraft,
- additional MEL restrictions,
- extensive health monitoring procedures for propulsion systems, commitment to incorporate CMP quick-action items.

Operational Approval considerations

When considering an application for an accelerated ETOPS Operational Approval, the authority must be satisfied that the standards established by the operator are equivalent to those operating standards which would normally be expected after 12 moths of in-service experience. Particular attention will be paid to:

- the operator's overall safety record,
- past performance,
- flight crew training,
- maintenance training,
- maintenance programs,
- control procedures when maintenance support is provided by some other organization,
- control and checking procedures when flight dispatch (including computerized flight planning, meteorological information, load and balance data) is provided by some other organization.

3.2.2 Operator's propulsion system reliability

The propulsion system will have demonstrated over the world-wide fleet an established IFSD rate consistent with the Operational Approval sought. The operator will demonstrate, to the satisfaction of the authority, how it will maintain this level of propulsion system reliability.

3.2.3 Engineering modification and maintenance program

Maintenance and training procedures, practices and limitations established for extended-range operations must be considered suitably.

A reliability reporting procedure must be in place and demonstrated.

The operator must show an established procedure for prompt implementation of modifications and inspections which could affect propulsion system and airframe system reliability.

The engine condition monitoring program must be demonstrated to be established and functioning.

The oil consumption monitoring program must be demonstrated to be established and functioning.

3.2.4 Flight dispatch

The operator must demonstrate to the satisfaction of the authority that dispatch procedures are in place and are satisfactory for the operation being conducted. An operator with no previous ETOPS experience may obtain support from an established

ETOPS operator or vendor of computerized flight planning and operational services to facilitate ETOPS dispatch, but this does not in any way absolve it from the responsibilities for control and checking of such procedures. Flight crews must demonstrate their ability to cope with pre-departure and en-route changes to planned route, en-route monitoring and diversion procedures. Both flight dispatch staff and flight crews must demonstrate familiarity with the routes to be flown, in particular the requirements for and the selection of en-route alternates.

3.2.5 Flight crew training and evaluation program

The operator must demonstrate a training and evaluation program that fulfils all the requirements. The authority will be satisfied, by simulated ETOPS operations using the normal dispatch procedures and an approved flight simulator, that the crew members nominated as ETOPS-qualified by the operator are properly trained and capable of dealing with any situation which might be encountered during extended-range operations. Such demonstrations must include a change of planned route, emergency procedures, diversions to en-route alternate, following both an engine failure and, on a separate occasion, a total pressurization failure, and the flight profile to meet the critical fuel scenario requirements.

3.2.6 Operational limitations

Operational Approvals which are granted after taking advantage of reduced in-service experience will be limited to specified routes. The routes approved will be those demonstrated to the authority during the execution of the Accelerated ETOPS Operational Approval Plan. When an operator wishes to add routes to the approved list, additional demonstrations associated with maintenance capability at the new destination and dispatch and en-route procedures for the new route must be conducted to the satisfaction of the authority.

3.2.7 ETOPS operations start-up

Operators who successfully demonstrated a capability consistent with the standards required for an Operational Approval with 120-minute diversion time may be required to progress to this level of approval in steps in accordance with a Notice of Proposed Amendment (NPA number 1) of the regulations:

- Operators who have experience as ETOPS operators and experience with similar technology aircraft and similar technology engines can apply for a 120-minute diversion time Operational Approval at entry into service.
- Operators who have previous long-range experience and experience with similar technology aircraft and similar technology engines can apply for a 90-minute diversion time Operational Approval at entry into service, and must complete a three-month period and a minimum of 200 sectors with a measured operational reliability of 98% before progressing to a 120-minute approval.

- Operators who have no previous long-range experience but who obtain appropriate maintenance and operational support from an established ETOPS-approved organization can apply for a 90-minute Operational Approval and must complete a three-month period and 300 sectors with a measured operational reliability of 98% before progressing to a 120-minute approval.
- Operators who intend to commence ETOPS operations with staff who have gained appropriate experience with other ETOPS-approved operators can apply for 75-minute diversion time Operational Approval and must complete 200 sectors with a measured operational reliability of 98% before progressing to a 90-minute approval, and then must complete a further three-month period and 300 sectors with a measured operational reliability of 98% before progressing to a 120-minute approval.
- Operators who intend to progress to a 138-minute diversion time Operational Approval (120-minute plus 15% on the basis of the 120-minute ETOPSCMP) must demonstrate their suitability and must complete a minimum of 200 sectors with a measured operational reliability of 98% under the 120-minute approval.
- Operators who intend to progress to a 180-minute diversion time Operational Approval must demonstrate one year's satisfactory and extensive operation at a maximum diversion time of not more than 138 minutes.

3.2.8 Accelerated ETOPS surveillance

Operators must be aware that any deficiencies associated with engineering and maintenance programs, flight dispatch or flight crew performance may result in the rejection of, or amendment to, the claimed credit for reduced in-service experience.

Therefore, an accelerated program leading to an Operational Approval is considered feasible so long as the operators remain commited to the standards which are contained in their ETOPS Operational Approval Plan and associated programs, and the first year of operation will be closely monitored.

3.2.9 Simulated ETOPS during proving period

As already mentioned, an operator can claim a reduction in the proving phase to get operational approval by simulating ETOPS operations over non-ETOPS routes

Simulating ETOPS consists of applying ETOPS requirements for a normal flight. Maintenance staff, dispatcher and crews are concerned and must completely play their respective roles to validate the process.

Advantages:

- Simulated ETOPS help all involved people of the airline to get familiar with the requirements.
- The airline will be ready at the start of ETOPS operations.

At the end of such a period of simulated ETOPS flights, the airline should be familiar with the whole ETOPS procedure and ready to start ETOPS operations in good conditions. This experience should be very helpful to get ETOPS Operational Approval and to give confidence to the national authorities in the airline's ability to conduct ETOPS operations.

3.2.10 138-minute ETOPS approval criteria

Since 1995 it exists an optional ETOPS approval between 120 and 180 minutes. JAA, first, has given 138-minute (120+15%) approval to European operators conducting 120-minute ETOPS operations.

The ETOPS approval with 138-minute diversion time is obtained on the basis of the approval with 120-minute diversion time, this means without having to comply with all the extra requirements applicable for approval with 180-minute diversion time.

The increased diversion time up to 138 minutes allows the removal of any operational constraints that may exist with 120 minutes and offers greater operational flexibility. In addition, wherever 138 minutes is sufficient, it allows significant benefits as compared with the 180-minute ETOPS requirements, in particular for fuel reserves, for MEL and for capacity of the cargo fire protection systems.

In addition, an increased number of adequate en-route alternate airports could be offered in certain areas.
Both JAA and FAA agree on the application of the 120-minute CMP requirements. However, they slightly differ on the MEL requirements. For the JAA, specific items for 138-minute diversion time have to be considered in the operator's MEL, whereas for the FAA, the application of the 120-minute operators MEL is sufficient, although some specific restrictions may be required.

In addition, with regard to the aircraft equipments, and more particularly for the capacity of the cargo fire protection system, the JAA requires the application of the basic rules. This means 138 plus 15 minutes, whereas the FAA is less stringent by requiring 120 plus 15 minutes only.

It's useless to take credit of the 120-minute extension, the operator should ensure that the candidate aircraft has obtained the ETOPS Type Design Approval with at least a 138-minute diversion time.

Airlines with the existing 120-minute or greater approval may apply for 138-minute ETOPS by application letter which must include the following information:

- summary of present approval,
- airframe/engine combination presently being used by the airline,
- airframe/engine combinations for which 138-minute ETOPS application applies,
- engine shutdown rates for existing airframe/engine combinations included in the 138-minute ETOPS application,

- area of operations requested for 138-minute ETOPS operations (Atlantic, Pacific, etc.),
- training curriculum to be used identifying 120 versus 138-minute ETOPS criteria.

4 Preparing ETOPS Operations

4.1 Definitions

ETOPS Operations

ETOPS operations apply to all flights conducted in a twin-engined aircraft over a route that contains a point further than 60 minutes flying time from an adequate airport at the selected one-engine-out diversion speed schedule in still air and ISA conditions. It's based on single-engine flying time to an adequate airport (75, 90, 120 or 180 minutes).

ETOPS operations requires specific regulations and operational procedures application.

Suitable Airport

A suitable airport for dispatch purposes is an airport confirmed to be adequate which satisfies the ETOPS dispatch weather requirements in terms of ceiling and visibility minima (refer to weather reports and forecasts) within a validity period. This period opens one hour before the earliest Estimated Time of Arrival (ETA) at the airport and closes one hour after the latest ETA. In addition, cross-wind forecasts must also be checked to be acceptable for the same validity period.

Field conditions should also ensure that a safe landing can be accomplished with one engine and / or airframe system inoperative.

Diversion / en-route alternate airport

A "diversion" airport, also called "en-rout alternate" airport, is an adequate / suitable airport to which a diversion can be accomplished.

Maximum diversion time

The maximum diversion time from an en-route alternate airport is granted by the operator's national authority and is included in the individual airline's operating specifications.

It's only used for determining the area of operation, and therefore is not an operational time limitation for conducting a diversion which has to cope with the prevailing weather conditions.

Maximum diversion distance

The maximum diversion distance is the distance covered in still air and ISA (or delta ISA) conditions within the maximum diversion time at the selected one-engine-out diversion speed scheduled and at the associated cruise altitude (including the descent from the initial cruise altitude to the diversion cruise altitude). It is used for dimensioning the area of operations.

ETOPS area of operation

The ETOPS area of operation is the area in which it's authorized to conduct a flight under ETOPS regulations and is defined by the maximum diversion distance from an adequate airport or set of adequate airports. It's represented by circles centered on the adequate airports, the radius of which is the defined maximum diversion distance.

ETOPS entry point (EEP)

The EEP is the point located on the aircraft's outbound route at one hour flying time, at the selected one-engine-out diversion speed scheduled (in still air and ISA conditions), from the last adequate airport prior to entering the ETOPS segment. It marks the beginning of the ETOPS segment.

ETOPS segment

ETOPS segment starts at the EEP and finishes when the route is back and remains within the 60-minute area from an adequate airport. An ETOPS route can contain several successive ETOPS segments well separated each other.

Equitime Point (ETP)

An Equitime Point is a point on the aircraft route which is located at the same flying time from two suitable diversion airports. The ETP position can be determined using a computerized flight planning, or graphically on a navigation or plotting chart.

Critical Point (CP)

The critical point is the point on the route which is critical with regard to the ETOPS fuel requirements if a diversion has to be initiated from that point. The CP is usually, but not always (depending on the configuration of the area of operation), the last ETP within the ETOPS segment (it's useless that the last ETP is not necessarily the ETP between the last two alternate airports. Therefore, the CP has to be carefully determined by computation.

One-engine-out diversion speed

The one-engine-out diversion speed is a Mach/ISA speed combination selected by the operator and approved by the operational authority. The Mach is selected at the beginning of the diversion descent down to the transition point where the indicated Airspeed (IAS) takes over.

The one-engine-out diversion speed for the intended area of operations shall be a speed, within the certified operating limits of the aircraft which are Green Dot speed (minimum maneuvering speed and V_{MO} / M_{MO} (maximum certified operating speed), considering that the remaining engine thrust is at Maximum Continuous Thrust (MCT) or less.

An operator is expected to use this speed in case of diversion following an engine failure. However, as permitted by operational regulations, the pilot in command has the authority to deviate from this planned speed after completion of the assessment of the actual situation.

4.2 Area of operation

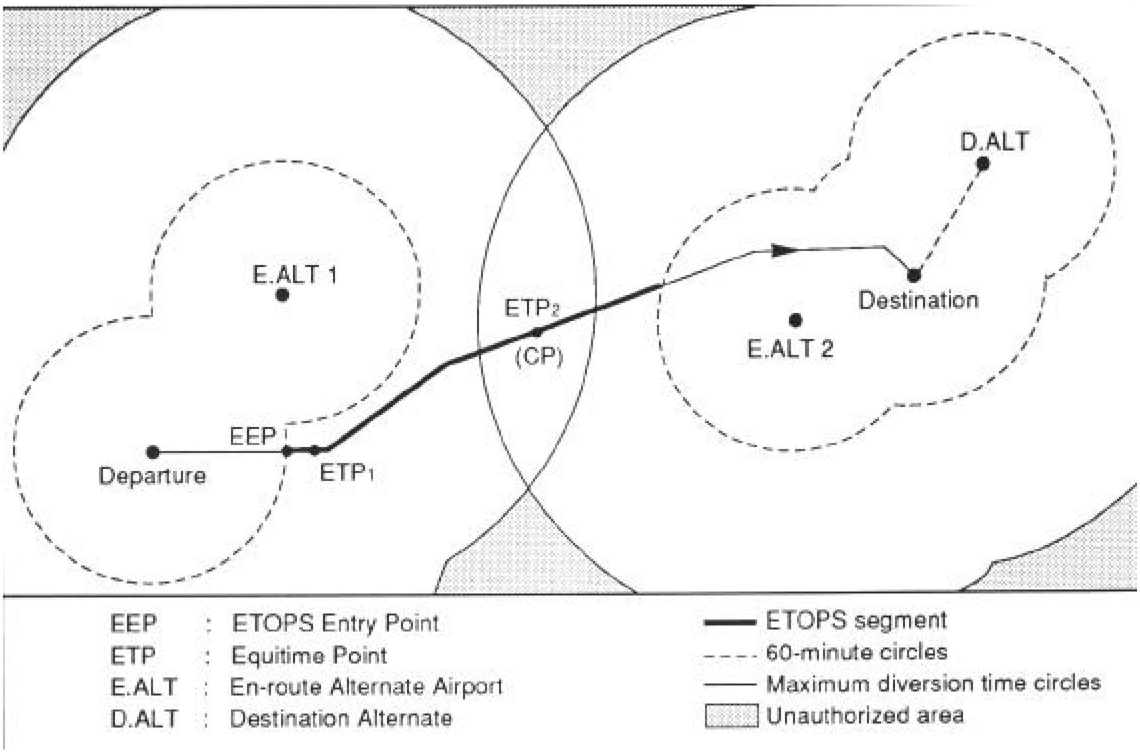

Fig. 5 ETOPS Area Of Operation [2]

ETOPS operations are allowed within a well-defined area of operation Fig. 5. The size of this area depends on the maximum diversion time granted to the airline, the selected one-engine-out diversion speed scheduled and the number and location of the selected adequate diversion airports.

The area of operation is determined in still air and ISA conditions, considering the relevant aircraft performance with one engine inoperative, the remaining engine being at MCT or less. Therefore, the area of operation is determined once, and does not require to be reassessed for each flight (considering the en-route weather forecast or the aircraft performance depending on the take-off weight) unless one or more adequate diversion airports happen to be unsuitable.

For some specific geographical areas where the temperature deviation from ISA is essentially constant all through, the operational authorities agree to determine the area of operation, considering this specific delta ISA condition at the typical one-engine-out diversion altitude.

The aircraft performance level considered for the calculation is associated to a unique aircraft weight which is called the aircraft reference weight.

4.2.1 Aircraft reference weight

The concept of reference weight has evolved with time. Previously, according to CAA regulations (CAP 513), the aircraft reference weight was the aircraft weight after two flight hours considering a take-off at the maximum take-off weight. At present, JAA and FAA have agreed not to give a definition of the reference weight, but to leave the operator free to determine its own reference weight having regard to the ETOPS routes structure. This weight should be as realistic as possible and submitted for approval to the airline's operational authority.

It's suggested that the aircraft reference weight should be defined as the highest of the estimated gross weight values at the critical points of the various routes being considered within the given area of operation. The computation will be done considering a take-off at the maximum take-off weight (structural or runway limitation) and a standard speed scheduled, in still air and ISA (or delta ISA) conditions.

Whenever applicable, the above computation should be conducted considering that a given route may be supported by different sets of declared en-route alternates (thus resulting in different CP locations).

4.2.2 Diversion speed schedule and maximum diversion distance

Considering the aircraft reference weight and the selected one-engine-inoperative diversion speed schedule, it's possible to determine the optimum diversion cruise flight level, providing the best True Air Speed (TAS).

Basically the resulting TAS at the diversion flight level, combined with the maximum diversion time allowed, provides the maximum diversion distance. However, an agreed interpretation of the regulation is to take benefit of the descent (during which the TAS is higher than during the diversion cruise) to increase the maximum diversion distance

4.3 ETOPS fuel requirements

4.3.1 General fuel requirements

An aircraft is allowed to be dispatched provided sufficient fuel is loaded to conduct the intended flight. The fuel quantity required is determined by the applicable operational regulations.

Unlike the area of operation which is determined in still air and ISA conditions (or prevailing delta ISA), the fuel planning must consider the expected meteorological conditions along the considered routes (forecast wind component and temperature).

For dispatching an aircraft for an ETOPS flight, the dispatcher must determine, for the considered route, both a standard (Fig. 6) and an ETOPS fuel planning. The highest of both fuel requirements shall be considered as being the minimum required block fuel for the flight.

For ETOPS operation, a specific ETOPS fuel planning – also called Critical Fuel Reserves in the regulations – should be established.

The ETOPS fuel planning is split into two parts:

the first part corresponds to a standard fuel scenario Fig. 6 from the departure airport to the Critical Point and the second part corresponds to the critical fuel scenario from the CP to the diversion airport.
The ETOPS critical fuel scenario is based on the separated study of two failure cases, occurring at the point, with their respective diversion profiles.

4.3.2 Critical fuel scenario

This scenario is based on a failure case occurring at the CP and requiring a diversion. The point of occurrence is so called "critical" because in terms of fuel planning a diversion at this is the least favorable.

The diversion profile is defined as follows:

- descent at a pre-determined speed strategy to the required diversion flight level,
- diversion cruise at the pre-determined speed,
- normal descent down to 1.500ft above the diversion airport,
- 15 minutes holding at this altitude,
- first approach (IFR) an g-around,
- second approach (VFR) and landing.

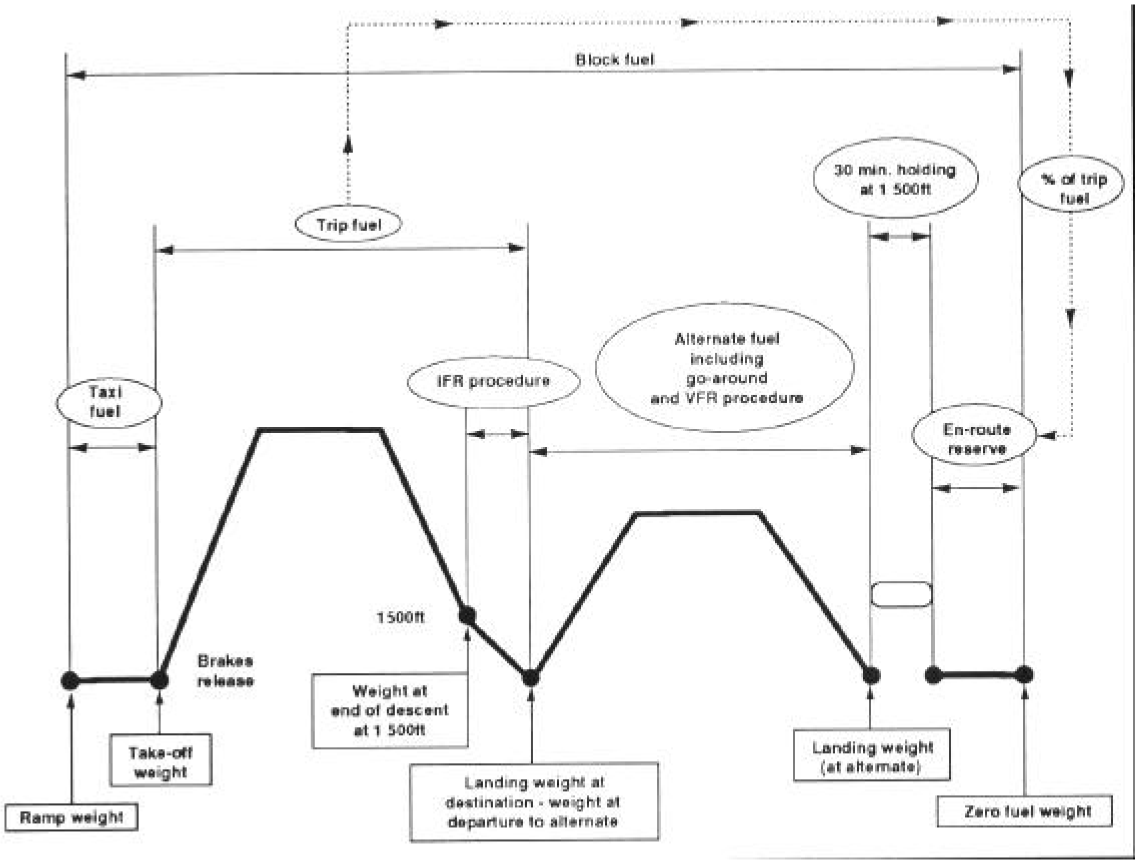

Fig. 6 Fuel Plan (example: Standard Fuel Plan) [2]

The complete ETOPS fuel planning for the ETOPS critical fuel scenario must be compared to the standard fuel planning (Fig. 6) computed in accordance with the company fuel policy and applicable operational requirements. The highest of both fuel requirements shall be considered as the required block fuel for the flight. Therefore, the pilot is then assured of safely completing the flight whatever the flight scenario is (normal flight or diversion).

4.4 ETOPS dispatch weather minima

Due to the natural variability of the weather conditions with time, as well as the need to determine the suitability (during a defined period of validity) of a particular en-route alternate airport prior to departure for an ETOPS flight, the en-route alternate dispatch weather minima are generally higher than the normal weather minima necessary to initiate an instrument approach. This is necessary to assure that the instrument approach can be conducted safely if the flight has to divert to this en-route alternate airport.

The ETOPS dispatch weather minima may slightly differ from one regulation to another:

- For the FAA, higher than normal ETOPS dispatch weather minima are meat to account for the possible degradation of the weather conditions at the diversion airports,

- For the JAA, in addition to the FAA definition, the ETOPS dispatch weather minima also account for the possible degradation of the let-down aids capability.

Circling minima are not taken into account for ceiling minima. However, if the weather forecast requires the consideration of a circling approach, refer to airport approach chart to determine the relevant ETOPS dispatch ceiling minima by adding 400ft to the published circling minima.

For geographical areas where weather conditions are very stable, this means that the variations are well known and occur at a Low rate, a decrease of the dispatch minima could be considered after agreement with the operator's operational authorities.

It's worth recalling that all Airbus aircraft are category C for the determination of the normal minima. Minima are normally provided in the approach and landing charts.

4.5 MEL (Minimum Equipment List)

The operator's MEL is based on the Master Minimum Equipment List (MMEL) established by the aircraft manufacturer. The MMEL is approved by the DGAC for all Airbus models certified for ETOPS and includes the required additional restrictions for the ETOPS operations. These restrictions have been established in accordance with the aircraft's maximum certified diversion time (for example, for operations beyond 120 minutes diversion time, the APU is required to be operative for A310 and A300-600 models).

5 Dispatching the ETOPS Flight

5.1 Introduction

The operator must ensure that each aircraft approved for ETOPS is correctly operated and supported in accordance with the terms of the ETOPS Operational Approval.

Dispatching an ETOPS flight is basically processed as a normal flight but with some additional specific aspects related to ETOPS operations.

The success of the ETOPS operations is essentially dependent on the quality of the flight preparation. Therefore, a successful ETOPS flight preparation is achieved by collecting, processing and transmitting to the flight crew all relevant information to safely and economically conduct the flight. Dispatchers and flight crew should then work in close coordination.

The following paragraph describes the tasks assigned to the dispatcher.

5.2 Dispatch requirements, suitable airports determination

As early as possible, the dispatcher should be aware of all information which could result in operational limitations. This information will then be transmitted to the flight crew.

Therefore, it's necessary that the maintenance department issues an ETOPS release statement for each aircraft to be operated, to inform the CMP document at the latest revision. Depending on the maintenance report, the airline's maximum diversion time may be modified for any technical reason (for example, on A300-600R, operations beyond 120 minutes is not allowed when the APU is not serviceable). In such an occurrence a flight plan rerouting may have to be considered.

Also, MEL and CDL (Configuration Deviation List) items can introduce dispatch requirements and / or limitations (e.g. additional fuel factors).

Thus, the availability of all relevant information to the dispatch office must be assured without delay in order to avoid re-routing the flight at the last minute whenever limitations are effective.

Therefore, to ensure the success of the ETOPS operations an appropriate coordination between the dispatch and maintenance groups is of paramount importance.

One of the distinguishing features of ETOPS operations is the concept of a "suitable" airport which should apply to the required "adequate" en-route alternate airports for ensuring the feasibility of the intended route for a given flight. An en-route adequate airport is declared as suitable when:

- weather forecasts for this airport are better than the ETOPS required dispatch weather minima for a defined period of time as explained in Chapter 4,

- applicable NOTAMs ensure that the required en-route alternate airport is and will remain available (no reduction in ground services, runway availability, let-down aids, etc.) for the same time period,
- surface crosswind forecast and runway conditions are within acceptable limits to allow a safe approach and landing with one engine inoperative.

For certain routes, the departure and/or destination airports are considered as ETOPS en-route alternate airports, this requires that they must meet the above conditions to be declared as suitable.

Therefore, when the suitability of a required en-route alternate airport is not ensured, the ETOPS flight may not be possible unless either redundant suitable airports are available or a modification of the routing is done accordingly. Then, an ETOPS flight can be dispatched, provided that sufficient suitable airports are declared to cover the intended area of operation.

5.3 Flight crew documentation

During the flight preparation, the dispatcher will collect and process relevant information which will be presented to the flight crew under the following documents.

5.4 Flight crew preparation

The flight crew will review the flight documentation which should include:
- NOTAMs for departure, destination, destination alternate and ETOPS en-route alternate airports,
- meteorological forecast and reports for the same airports and en-route wind and temperature forecast,
- ATC flight plan,
- any particular diversion strategy specific to the route (minimum time, obstacle clearance, etc.),
- CFP, which usually include all the above items,
- navigation and plotting charts with ETOPS relevant information,
- any other documents (i.e. airport, route, area briefings, etc.) as per company practices.

CFP fuel and time predictions are in general very accurate; however, it's the duty of the crew to perform the following checks to detect any possible gross error:

- conformity of the CFP routing with ATC flight plan,
- type of aircraft, date, estimated time of departure (ETD), estimated ZFW/TOW/FOB,
- wind data compared to en-route MET forecast,
- trip fuel, fuel to alternate, ETOPS fuel from ETPs to en-route alternates compared to FCOM (including performance factor).

5.5 Equitime Points location

5.5.1 No-wind conditions

In no wind conditions, the ETOPS ETPs between two alternate airports can be geometrically determined. It's the intersection point between the route and the chord of the arcs generated by the overlap of the two circles centered on the two considered alternate airports. The following figure (Fig. 7) illustrates the above statement.

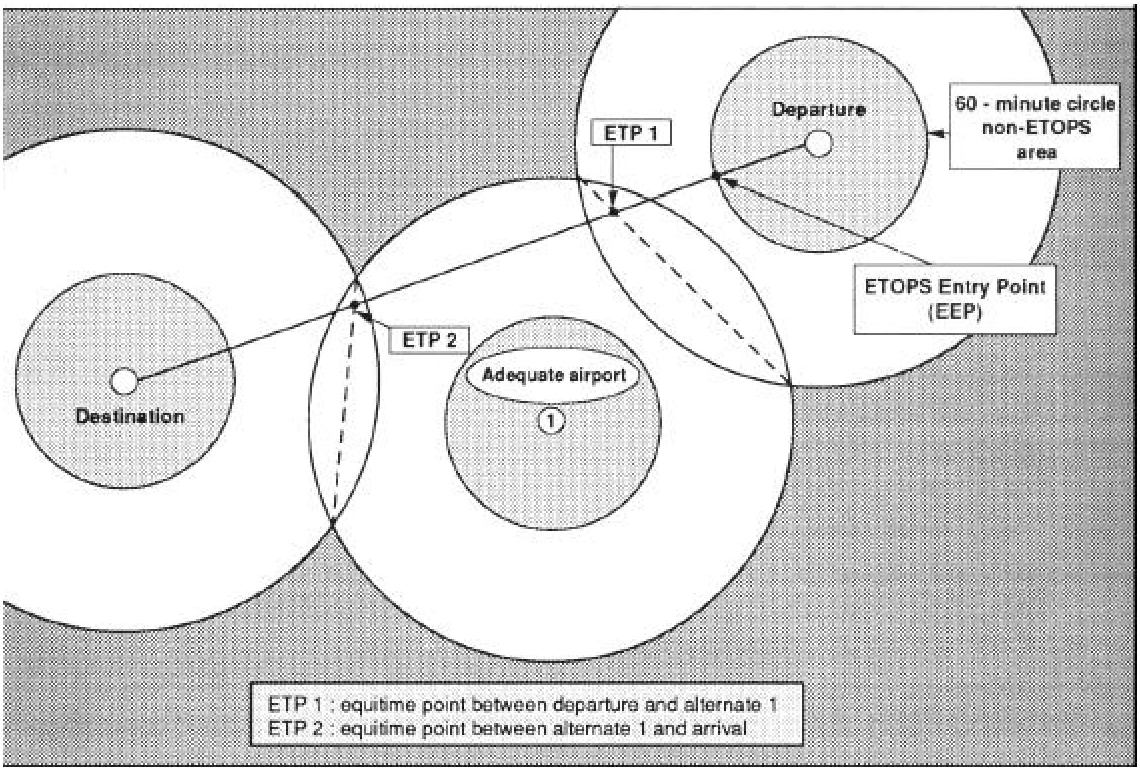

Fig. 7 Equitime Point Location, no wind [2]

5.5.2 Wind conditions

In wind conditions, the ETPs position must be corrected by the wind effect.
The "equitime graph" (graph valid for a given TAS) provided below can be used to determine the on-track ETP between two alternate airports located either on- or off-track. The following data are necessary to use the method:

distance between these two diversion airports (in nm),
wind component from the on-track midpoint (no-wind) to the continuing alternate airport (continuing wind component),
wind component from the on-track midpoint (no-wind) to the returning airport (returning wind component).

5.6 Unexpected closure of en-route alternate airport

When dispatching a flight for a non-ETOPS sector, as soon as the dispatch office is informed of an unexpected closure of en-route alternate airport the consequence of which is to revert to an ETOPS sector, the flight may have to be re-routed (to remain non-ETOPS) or cancelled.

However, for particular non-ETOPS sectors where some essential en-route alternate airports are regularly closed or permanently closed for a well-determined period of time (for example, in winter for weather reasons such as the lack of snow removal equipment), operators have to anticipate being prepared to apply the requirements for a 75-minute ETOPS operation, as specified by FAA and now by JAA.

It should be noted that, for 75-minute operations, an approval has to be obtained from the national operational authorities, but the approval requirements are less stringent than for a 90-minute approval, this means that not all requirements of the basic regulations need necessarily to be met.

For an ETOPS operator, when dispatching an ETOPS flight and facing an unexpected closure of en-route alternate airport or its non-suitability for dispatch weather minima reason, thereby modifying the area of operation, the flight may have to be re-routed or cancelled.

However, in order to help operators to avoid flight re-routing or cancellation, the operational authorities may agree to slightly increase the diversion time for specific routes if it can be shown that the resulting routing does not jeopardize flight safety. This applies to operations cleared up to 120-minute diversion time, provided such an increase:

- does not exceed the limitations given in the aircraft ETOPS type design approval,
- is not more than 15% of the operator's original maximum diversion time.

To fully take benefit (or credit) of this regulations item, the operator should anticipate the possible closure of an adequate airport and be ready to dispatch the flight with the increased diversion time, whenever it's required. Consequently the 15% increment should be provisioned in the operator's operational specifications.

6 On-Board Flight Crew Procedures

6.1 Cockpit preparations

Additional System Checks

example for an Airbus A310/A300-600:

- check of standby generator.
  - Except for aircraft under US registration, this test is not required by certification. However, it has been made mandatory by most authorities at the operational approval level.
- Check of fuel cross-feed valve.

example for an A320/A321 and A330:

- Check of emergency electrical generator,
- Check of APU and APU Generator,
- Check of fuel cross-feed valve.

6.2 After engine start procedure

After engine start, ECAM STATUS page is checked. Failures which were known at the time of the flight preparation are normally already covered by MEL entries. Additional failures may occur which require the crew to proceed as per company policy to dispatch the aircraft.

At this point MEL ETOPS restrictions must be observed.
As soon as the aircraft is moving under its own thrust, it's usually considered that the flight has commenced, this means that the MEL does not apply any longer. However, the decision to depart with a failure condition is left to the Captain who may decide for operational or even economical reasons to repair the aircraft at the departure airport.

NOTE: For an ETOPS flight, as for a normal flight, the MEL does not apply once the aircraft is airborne

6.3 In flight procedures

6.3.1 Operations flight watch

Depending of the profile of the intended flight route, a flight watch from the dispatch office to support the crew during the flight is recommended.

The flight watch office should be equipped with appropriate means of Communication to contact the aircraft in the air at any or predetermined times.

Normally an HF Communication system is used, but ACARS, SATCOM systems could also be utilized.

The flight watch team should collect any relevant information for the current flight operation including:
- update of weather forecasts and reports for ETOPS en-route alternates,
- update of en-route weather forecasts at cruise altitude but also at lower altitude including FL100,
- sigment,
- NOTAMs, SNOWTAMs etc.

The flight watch office should also be ready to assist the crew if a diversion is required following a failure (re-routing, fuel status reassessment).

6.3.2 Weather update -before ETOPS Entry Point

With the support of flight watch or by their own means, the crew must make every effort to obtain weather forecasts and reports for ETOPS en-route alternates. Weather forecasts at the estimated time of arrival at the en-route alternate airports must be higher than the normal minima.

Note: The ETOPS dispatch minima do not apply when airborne.

If weather forecasts are lower than the normal crew minima, then re-routing is required, or turnback if no route at the authorized distance from an en-route alternate airport can be used.

6.3.3 Weather update -after ETOPS Entry Point

The crew should continue to update the weather forecasts and reports for en-route alternates. There is no requirement to modify the normal course of the flight if the weather degrades below minima.

As for normal flight, the crew must make every effort to keep themselves informed on the weather at the destination and the destination alternate.

6.3.4 Fuel monitoring

The procedures normally used as per airline policy is also applicable for ETOPS.

This is true even for flights where ETOPS fuel planning is the limiting factor.

There are no requirements in the ETOPS rules to reach the CP with the Fuel On Board (FOB) being at least equal to the fuel required by the critical fuel scenario.

This means that the CP should not be considered as a reclearance point. Therefore, if during the flight it appears that the estimated FOB at the CP will be lower than the fuel required by the critical fuel scenario, there is no requirement to make a diversion, provided the estimated fuel at the destination is above the minimum required to divert to the destination alternate. Normal rules apply.

However, it's recommended that if the CP is regularly overflown with a FOB lower than the fuel required by the critical fuel scenario, the appropriate corrective actions should be taken in the way the required fuel is determined at dispatch (i.e. increase performance factor, route reserves, etc.).

6.3.5 Navigation monitoring

In most cases, ETOPS flights are conducted in areas outside radio-navaid coverage. If the aircraft remains for a long period of time in IRS-Only NAVIGATION, then some specific procedures, which are not directly linked to ETOPS, need to be considered. This is also true for flights within the MNPS (Minimum Navigation Performance Specification) area or in the polar regions (A330).

Airbus Industrie FCOM bulletins deal with these aspects of long-range navigation monitoring, except of these procedures are not given here, but the main points are summarized, as one way (but not the only way) to achieve the same result.

6.3.6 Diversion decisions-making

The Airbus recommendations and guidelines for in-flight-re-routing or diversion decision-making are published in the A310/A300-600 FCOM [3], and in the A320/A330 FCOM [4].

The technical criteria governing a re-routing or diversion decision can be classified in four categories, as follows:

- loss of MNPS capability, before entering the MPS area (as applicable),
- weather minima at diversion airport(s) going below the company / crew en-route minima, before reaching the EEP, or diversion airport(s) becoming unsuitable for any reason,
- failure cases requiring a diversion to the nearest airport (cases leading to a LAND ASAP message on the ECAM and / or in the QRG),
- failure cases resulting in excessive fuel consumption, exceeding the available fuel reserves.

Some failures related to electrical generation (table 4) required special consideration for ETOPS:

Table 4 Electrical Generation Failure

	1st ENG-GEN failure	HYD.LO LVL (blue for A320/A321) (green for A310/ A300-600/A330)
A310 , A300-600	Start APU*	Start APU*
A320,A330	Start APU diversion required if APU GEN is not available.	Start APU diversion required if the APU GEN is not available.

** Diversion is not required if APU GEN is not available; however, crew should evaluate the operational situation and take a decision accordingly.*

In case of a cargo fire, diversion to the nearest suitable airport is mandatory, whatever is the performance, in term of protection time, of the fire-extinguishing system. Nevertheless, the final decision belongs to the crew who may choose a more distance airport for operational reasons or considering more appropriate airport safety equipment.

6.3.7 Conducting a diversion

Whatever one-engine-inoperative speed schedule is assumed in the determination of the area of operation, the crew is free to adopt the strategy it considers the most appropriate after assessment of the overall situation. This means that in conducting the diversion the application of the preplanned speed strategy is not mandatory.

However, each time a time-dependent situation occurs, the crew should conduct the diversion at the maximum speed.

Crews should first refer to the route instruction given in the Airlines Operations Manual or in separate route documentation in which they will find the diversion strategy relative to the route.

7 Reference

[1] Airbus Industrie: *ETOPS.* Toulouse, Ref. AI/CS-K No 174/85: Dec. 1985

[2] Airbus Industrie: *First ETOPS Conference* , Presentation: February 1994

[3] Airbus Industrie: *A310/A300-600 FCOM,* 2.18.70 § 5, pages 4 and 5

[4] Airbus Industrie: *A320/A330 FCOM,* 2.04.40

AIRBUS INDUSTRIE
1, r.p. Maurice Bellonte
BP 33
F-75781 Paris Cedex
Tele.: 0033 5 61 93-3333

DaimlerChrysler Aerospace
Airbus GmbH
Kreetslag 10
21129 Hamburg
Tele.: 0049 40 7437-0

Appendix

FAA section 121.161

Airplane limitations: Type of route.

(a) Unless authorized by the Administrator, based on the character of the terrain, the kind of operation, or the performance of the airplane to be used, no certificate holder may operate two-engine or three-engine airplanes (except a three-engine turbine powered airplane) over a route that contains a point farther than 1 hour flying time (in still air at normal cruising speed with one engine inoperative) from an adequate airport.

(b) Except as provided in paragraph (c) of this section, no certificate holder may operate a land airplane (other than a DC-3, C-46, CV-240, CV-340, CV-440, CV-580, CV-600, CV-640, or Martin 404) in an extended overwater operation unless it is certificated or approved as adequate for ditching under the ditching provisions of part 25 of this chapter.

(c) Until December 20, 2010, a certificate holder may operate, in an extended overwater operation, a nontransport category land airplane type certificated after December 31, 1964, that was not certificated or approved as adequate for ditching under the ditching provisions of part 25 of this chapter.

[Amdt. 121-22, 31 FR 13078, Oct. 8, 1966 and Amdt. 121-162, 45 FR 46739, July 10, 1980, as amended by Amdt. 121-251, 60 FR 65927, Dec. 20, 1995]

JAR-OPS 1.245

Maximum distance from an adequate aerodrome for two-engined aeroplanes without an ETOPS Approval

(a) Unless specifically approved by the Authority in accordance with JAR-OPS 1.246(a) (ETOPS Approval), an operator shall not operate a two-engined aeroplane over a route which contains a point further from an adequate aerodrome than, in the case of:

(1) Performance Class A aeroplanes with either:
- (i) A maximum approved passenger seating configuration of 20 or more; or
- (ii) A maximum take-off mass of 45360kg or more,

the distance flown in 60 minutes at the one-engine-inoperative cruise speed determined in accordance with subparagraph (b) below;

(2) Reserved.

(3) Performance Class B or C aeroplanes:
- (i) The distance flown in 120 minutes at the one-engine-inoperative cruise speed determined in accordance with subparagraph (b) below; or
- (ii) 300 nautical miles, whichever is less. (See IEM OPS 1.245(a).)

(b) An operator shall determine a speed for the calculation of the maximum distance to an adequate aerodrome for each two-engined aeroplane type or variant operated, not exceeding VMO, based upon the true airspeed that the aeroplane can maintain with one-engine-inoperative under the following conditions:
- (1) International Standard Atmosphere (ISA);
- (2) Level flight:
- (i) For turbojet aeroplanes at:
  - (A) FL 170; or
  - (B) At the maximum flight level to which the aeroplane, with one engine inoperative, can climb, and maintain, using the gross rate of climb specified in the AFM,

whichever is less.
- (ii) For propeller driven aeroplanes at:
  - (A) FL 80; or
  - (B) At the maximum flight level to which the aeroplane, with one engine inoperative, can climb, and maintain, using the gross rate of climb specified in the AFM,

whichever is less.

(3) Maximum continuous thrust or power on the remaining operating engine;

(4) An aeroplane mass not less than that resulting from:
- (i) Take-off at sea-level at maximum take-off mass; and
- (ii) All engines climb to the optimum long range cruise altitude; and
- (iii) All engines cruise at the long range cruise speed at this altitude,

until the time elapsed since take-off is equal to the applicable threshold prescribed in subparagraph (a) above.

(c) An operator must ensure that the following data, specific to each type or variant, is included in the Operations Manual:

(1) The one-engine-inoperative cruise speed determined in accordance with subparagraph (b) above; and

(2) The maximum distance from an adequate aerodrome determined in accordance with subparagraphs (a) and (b) above.

Note: The speeds and altitudes (flight levels) specified above are only intended to be used for establishing the maximum distance from an adequate aerodrome.]

JAR-OPS 1.246

Extended range operations with two-engined aeroplanes (ETOPS)

(a) An operator shall not conduct operations beyond the threshold distance determined in accordance with JAR-OPS 1.245 unless approved to do so by the Authority (ETOPS approval) (See AMC 20.xxx (Text for this AMC will be an appropriately modified version of the published JAA Information Leaflet 20).)

(b) Prior to conducting an ETOPS flight, an operator shall ensure that a suitable ETOPS en-route alternate is available, within either the approved diversion time or a diversion time based on the MEL generated serviceability status of the aeroplane, whichever is shorter. (See also JAR-OPS 1.297(d).)]

Information Leaflet No. 20

Temporary Guidance Material for Extended Range Operation with Two-Engine Aeroplanes ETOPS Certification and Operation

1 July 1995 (revised)

0 Foreword

a. General

As no JAR-OPS is available yet, it is not possible to have a detailed 'applicability and grandfather clause' paragraph in this Information Leaflet (IL), as initially proposed. Therefore the 'applicability and grandfather clause' paragraph is restricted to a reference to applicable operational rules (e.g. the ones enforced by the Authority of each JAA country).

The IL is therefore one means of compliance, but not the only one, to these applicable operational rules.

However, to achieve better consistency between the JAA countries, it was felt necessary to indicate the assumptions made when drafting the IL, and it is expected that these will normally be applied.

(1) The intended applicability was:

Twin-engine aeroplanes with a Maximum Take Off Weight (MTOW) exceeding 5700 kg and a passenger capacity above 19 seats, pilots excluded, or utilized as freighters engaged in commercial air transport operations over a route that contains a point further than 60 minutes at the approved in still air one-engine-inoperative cruise speed (under standard conditions) from an adequate airport. The controls proposed are designed to be appropriate to the intended operation.

(2) The intended grandfather clause was:
  (i) The issuance of this IL is not intended to alter the status of previous approvals (including type design and continued airworthiness and operation aspects).
  (ii) The case of derivative products (e.g. aeroplanes derived from previous models) is to be dealt with on a case by case basis; especially with respect to the 'third electrical source' capacity.

b. Harmonization with FAA

As harmonization is felt paramount by Authorities and Industry, a process of continuing coordination between JAA and FAA for further harmonization will be arranged and will probably lead to further revision of both the IL and FAA AC. The JAA ad-hoc group may be consulted by JAA for this process.
The topics to be covered will include:

(1) Engine reliability:
  (i) Continuous versus stepped approach
  (ii) Target reliability level
  (iii) Initial reliability level
  (iv) Pre-requisite service experience
(2) CMP Document:
  (i) JAA/FAA cooperation
  (ii) CMP for engines
  (iii) Revision of the CMP
(3) Operational Aspects:
  (i) Performance
  (ii) Dispatch
(4) APU Reliability
(5) Functions to be maintained in case of failure of normal power (electric/hydraulic/pneumatic).
(6) Assessment of Systems Reliability

c. Early ETOPS

Early Etops is not currently addressed in the IL.

1 Purpose

This Information Leaflet (IL) states an acceptable means but not the only means for obtaining approval under applicable operational rules for two-engine aeroplanes to operate over a route that contains a point further than one hour flying time at the approved one-engine-inoperative cruise speed (under standard conditions in still air) from an adequate airport. This IL allows a continuous curve of diversion time versus propulsion system reliability, however steps of diversion time may be necessary for practical reasons (e.g. 90 minutes, 120 minutes, etc). Operational requirements may also be related to diversion time.

The content of the IL will be related to diversion time as follows:

a by using the same set of criteria for design except that diversion time may be a parameter for the assessment of certain systems;

b. by applying the same set of criteria for maintenance;
c. by having two sets of operational criteria below and above 120 minutes.

This IL is similar to FAA Advisory Circular AC 120-42A dated 30.12.88. Differences between the two texts are indicated in accordance with normal JAA practice by underlining.

NPA 25E.F-235 ETOPS (AMJ 120-42)
JAR 25.901, JAR 25.903, JAR 25.1309, JAR-E 510, JAR-E 520
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