

Extended-range twin-engine operations (ETOPS)

Revision 0
4 May 2000

General

Civil Aviation Authority (CAA) Advisory Circulars contain information about standards, practices, and procedures that the Director has found to be acceptable for compliance with the associated rule.

Consideration will be given to other methods of compliance that may be presented to the Director. When new standards, practices, or procedures are found to be acceptable they will be added to the appropriate Advisory Circular.

Purpose

This Advisory Circular (AC) states an acceptable means by which approval may be given for NZ registered two-engine aeroplanes to operate over a route that contains a point farther than one hour flight time at the normal one-engine inoperative cruise speed (in still air) from an adequate aerodrome. Specific criteria are included for deviation of 75 minutes, 120 minutes and 180 minutes from an adequate aerodrome.

Related Rules

This Advisory Circular relates specifically to rule *121.165 En route limitations* and rule *121.167 ETOPS limitations*. This Advisory Circular contains data and information, which if included in a certificate holder's exposition would assist in the granting of an ETOPS approval.

Change Notice

Original issue

NOTE

This is an interim document effective whilst a Notice of Proposed Rule Making on ETOPS is being initiated. Upon adoption of the final rule pertaining to ETOPS operations this Advisory Circular will be cancelled. A new Advisory Circular will be associated with the final ETOPS rules.

Published by
Civil Aviation Authority
PO Box 31441
Lower Hutt

Authorised by
Assistant Director Rules and Standards

ISBN 0-478-11415-X

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Definitions

1.1 Adequate aerodrome – in relation to ETOPS

means an aerodrome that –

- (a) is associated with a Part 139 certificate or meets safety requirements equivalent to such an aerodrome; and
- (b) has suitable facilities and services available, for the aeroplane type concerned, that include—
 - (1) ATC or an aerodrome flight information service; and
 - (2) a meteorological reporting service; and
 - (3) at least one instrument approach procedure; and
 - (4) visual approach slope indicator system for turbojet and turbofan powered aeroplanes; and
 - (5) sufficient lighting

1.2 Suitable aerodrome – in relation to ETOPS

means an adequate aerodrome with weather reports, forecasts or combination thereof, indicating that the weather conditions will be at or above the minima outlined in Part 121 Subpart C, and the field condition reports indicate that a safe landing can be accomplished at the time of intended operation.

1.3 Auxiliary power units (APU)

means a gas turbine engine intended for use as a power source for driving generators, hydraulic pumps and other aeroplane accessories and equipment and/or to provide compressed air for aeroplane pneumatic systems.

An essential APU installation provides the bleed air and/or mechanical power necessary for the dispatch of a transport category aeroplane for operations other than extended-range operations with two-engine aeroplanes.

An APU installation which is intended to serve as one of the three or more independent alternating current (AC) electrical power sources required for extended-range operations provides the bleed air or mechanical power necessary for the safe flight of a two-engine transport category aeroplane approved for extended-range operation and is designed and maintained to provide a level of reliability necessary to perform its intended function

1.4 ETOPS configuration maintenance and procedures (CMP) standard

means the particular aeroplane configuration minimum requirements including any special inspection, hardware life limits, Master Minimum Equipment List (MMEL) constraints and maintenance practice found necessary by the Basic Certification Authority to establish the suitability of an airframe-engine combination for extended-range operation.

1.5 Engine

means the basic engine assembly as supplied by the engine manufacturer.

1.6 Extended-range operations

means, for the purpose of this Advisory Circular, extended-range operations are those flights conducted over a route that contain 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 aerodrome

1.7 Extended-range entry point

means the extended-range entry point is the point on the aeroplane's outbound route which is one-hour flying time at the approved single-engine inoperative cruise speed (under standard conditions in still air) from an adequate aerodrome.

1.8 Fail-safe

means the design methodologies upon which the FAR Part 25 airworthiness standards are based. It requires the effect of failures and combination of failures to be considered in defining a safe design. (Refer to Appendix 2 for a more complete definition of fail-safe design concepts.)

1.9 In-flight shutdown (IFSD)

means that when an engine ceases to function in flight and is shutdown, whether self-induced, crew initiated or caused by some other external influence (i.e. IFSD for all causes; for example; due to flame-out, internal failure, crew-initiated shut-off, foreign object ingestion, icing, inability to obtain and/or control desired thrust etc.).

1.10 System

means a system that includes all elements of equipment necessary for the control and performance of a particular major function. It includes both the equipment specifically provided for the function in question and other basic equipment such as that necessary to supply power for the equipment operation.

Airframe system means any system on the aeroplane that is not a part of the propulsion system.

Propulsion system means the aeroplane propulsion system that includes: each component that is necessary for propulsion; components that effect the control of the major propulsion units; and components which effect the safe operation of the major propulsion units.

2. Discussion

2.0 General

All two-engine aeroplanes operated under New Zealand Civil Aviation Rules, are required to comply with this Advisory Circular or an alternative acceptable means of compliance that meets the objectives of the rule. No Air Operator Certificate holder may operate two-engine or three-engine aeroplanes, except a three-engine turbine powered aeroplane, over a route that contains a point further than one-hour's flight time (in still air) at normal cruising speed with one engine inoperative from an adequate aerodrome. It is significant to note that this requirement is applicable to reciprocating, turbo-propeller, turbo-jet and turbo-fan aeroplanes transiting oceanic areas or routes entirely over land.

2.1 Background

Although these requirements evolved during the era of piston-engine aeroplanes and these requirements are currently applied to turbo-powered aeroplanes, which have significantly better reliability, experience has shown the present requirements to be effective and yet

flexible enough in their application to accommodate significant improvements in technology. Until recently, little consideration had been given to re-examining the viability of extending the permissible operating range of two-engine turbine-powered aeroplanes, by granting credit for improved reliability due to the limited range/payload capabilities of most of the existing generation of two-engine turbine-powered aeroplanes. However, some of the new generation two engine aeroplanes have a range/payload capability equivalent to many previous generation three and four-engine aeroplanes. The demonstrated range/payload capabilities of the new generation aeroplanes, including their provisions for achieving a higher degree of reliability, clearly indicate there is a need to recognise the capabilities of these aeroplanes and to establish the conditions under which extended-range operations with these aeroplanes can be safely conducted over oceanic and/or desolate land areas.

2.2 Historical basis

The United States has an extensive historical basis, which began as early as 1936. Their requirements in effect in 1936 required the applicant to show, prior to obtaining approval for the operation, that intermediate fields, available for safe take-off and landings, were located at least at 100-mile intervals along the proposed route. This restriction applied to all aeroplanes operating under this requirement regardless of the terrain or area overflown. Throughout the evolution of commercial aviation in the US the following factors have remained constant:

- (a) The rule has always applied to all areas of operation and has not been limited to over-water operation.
- (b) Any additional restrictions imposed, or alternatively any deviations granted to operate in excess of the basic requirements were based on a finding by the Federal Aviation Administration that adequate safety would be provided in the proposed operation when all factors were considered. This finding was never limited to engine reliability alone.
- (c) The aerodromes used in meeting the provisions of the requirement had to be adequate for the aeroplane used (i.e. available for safe landings and take-off at the weights authorised), and
- (d) In granting a deviation from the time restriction, the Federal Aviation Administration considered the character of the terrain, the kind of operation and the performance of the aeroplane, etc
- (e) In developing New Zealand aviation policy over the years it was necessary to study, and where applicable, adopt requirements from other nations that had proved to be satisfactory.

2.3 Certification standards and evaluation

To be eligible for extended-range operations, the specified airframe-engine combination should have been certificated to the airworthiness standards of transport category aeroplanes and should be evaluated considering the concepts in Section 4, evaluated considering the type design considerations in Section 5, evaluated considering the in-service experience discussed in Section 6, and evaluated considering the continuing airworthiness and operational concepts outlined in Section 7.

3. Application

Since large transport category aeroplanes in New Zealand are certificated in consideration of the Civil Aviation Rules Part 121, any consideration for deviation from these rules for two-engine aeroplane necessitates an evaluation of the type design to determine suitability of that

particular airframe-engine combination for the intended operation. This Advisory Circular provides guidance for obtaining type design, continued airworthiness and operations approval for those two-engine transport category aeroplanes intended for use in extended-range operations. The issuance of this Advisory Circular is not intended to alter the status of deviation previously approved in accordance with the Civil Aviation Rules. Although many of the criteria in this Advisory Circular may be currently incorporated into an operator's approved programme for other aeroplanes or route structures, the unique nature of extended-range operations with two-engine aeroplanes necessitates an evaluation of these operations to ensure that the approved programmes are effective. To the extent that changes in the aeroplane's type design, continued airworthiness, or the operations programme are involved as a result of this evaluation, they are approved through the normal approval processes

4. Concepts

4.0 Consideration of ETOPS related factors

Although it is self-evident that the overall safety of an extended-range operation cannot be better than that provided by the reliability of the propulsion systems, some of the factors related to extended-range operations are not necessarily obvious. For example, cargo compartment fire suppression/containment capability could be a significant factor or operational/maintenance practices may invalidate certain determinations made during the aeroplane type design certification, or the probability of system failures could be a more significant problem than the probability of propulsion system failures. Although engine reliability is a critical factor, it is not the only factor which should be seriously considered in evaluating extended-range operations. Any decision relating to extended-range operation with two-engine aeroplanes should also consider the probability of an occurrence of any condition which would reduce the capability of the aeroplane or the ability of the crew to cope with adverse operating conditions. The following is provided to define the concepts for evaluating extended-range operations with two-engine aeroplanes. This approach ensures that two-engine aeroplanes are consistent with the level of safety required for current extended-range operations with three and four-engine turbine powered aeroplanes without unnecessarily restricting operations:

4.1 Airframe system

A number of airframe systems have an effect on the safety of extended-range operations; therefore, the type design certification of the aeroplane should be reviewed to ensure that the design of these systems are acceptable for the safe conduct of the intended operation.

4.2 Propulsion system

A review of the historical data (1978 through 1988) for transport aviation two-engine turbo-fan-powered large commercial aeroplanes indicates that the current safety record, as exemplified by the world accident rate (airworthiness causes), is sustained in part by a propulsion system IFSD rate of only about .02/1000 hours. Although the quality of this safety record is not wholly attributable to the IFSD rate, it is believed that maintaining an IFSD rate of that order is necessary to not adversely impact the world accident rate from airworthiness causes. Upon further review of the historical database and in consideration of the required safety of extended-range operation, it is necessary that the achieved performance and reliability of the aeroplane should be shown to be sufficiently high. When considering the impact of increasing diversion time, it must be shown that the operation can be conducted at a level of reliability resulting in no adverse change in risk.

4.3 Maintenance reliability programme definition

Since the quality of maintenance and reliability programmes can have an appreciable effect on the reliability of the propulsion system and the airframe systems required for extended-range operation, an assessment should be made of the proposed maintenance and reliability programme's ability to maintain a satisfactory level of aeroplane systems reliability for the particular airframe-engine combination.

4.4 Maintenance and reliability programme implementation

Following a determination that the airframe systems and propulsion systems are designed to be suitable for extended-range operations, an in-depth review of the applicant's training programmes, operations and maintenance and reliability programmes should be accomplished to show ability to achieve and maintain an acceptable level of systems reliability to safely conduct these ETOPS operations.

4.5 Human factors

System failures or malfunctions occurring during extended-range operations could affect flight crew workload and procedures. Although the demands on the flight crew may increase, an assessment should be made to ensure that exceptional piloting skills or crew co-ordination are not required.

4.6 Approval basis

Each applicant (manufacturer or operator as appropriate) for extended-range approval should show that the particular airframe-engine combination is sufficiently reliable. Systems required for extended-range operations should be shown by the manufacturer to be designed to a fail-safe criteria and should be shown by the operator to be continuously maintained and operated at levels of reliability appropriate for the intended operation.

4.6.1 Type design ETOPS approval

Preceding the type design approval, the applicant should show that the airframe and propulsion systems for the particular aeroplane could achieve a sufficiently high level of reliability in service so that safe extended-range operations may be conducted. The achievement of the required level of propulsion system reliability is determined in accordance with Appendix 1 (See Paragraph 6.1). Evidence that the type design of the aeroplane is suitable for extended-range operations is normally reflected by a statement in the approved Aeroplane Flight Manual (AFM) and Type Certificate Data sheet or Supplemental Type Certificate (see Paragraph 5), which specifies the configuration, maintenance and procedures (CMP) standard requirements for suitability

4.6.2 In-service experience

It is also necessary for each operator desiring approval for extended-range operations to show that it has obtained sufficient maintenance and operations experience with that particular airframe-engine combination to safely conduct ETOPS operations. (See Paragraph 6.2)

4.6.3 Approval

The type design approval does not reflect a continuing airworthiness or operational approval to conduct extended-range operations. Therefore, before approval, each operator needs to demonstrate the ability to maintain and operate the aeroplane so as to achieve the necessary reliability and to train its personnel to achieve competence in extended-range operations. The operational approval to conduct extended-range operations is made by amendment to the operator's operations specifications (see Section 7), which includes requisite items provided in the AFM.

4.6.4 Continuing airworthiness

From time to time, the FAA or other certifying authorities may require that the type design CMP standard be revised to correct subsequent problems that impede the achievement of the required level of reliability. The FAA or other certifying authorities will initiate action as necessary to require a CMP standard revision to achieve and maintain the desired level of reliability and therefore, safety of extended-range operation. CMP standards in effect prior to revision will no longer be considered suitable for continued extended-range operation.

5. Type Design Approval Consideration

5.0 Design feature determination

When a two-engine type design aeroplane is intended to be used in extended-range operation a determination should be made that the design features are suitable for the intended operation. In some cases modifications to systems may be necessary to achieve the desired reliability. The essential airframe systems and the propulsion system for the particular airframe-engine combination should be shown to be designed to a fail-safe criteria and through service experience it must be determined that it can achieve a level of reliability suitable for the intended operation

5.1 Request for approval

An aeroplane manufacturer or other civil airworthiness authorities requesting a determination that a particular airframe-engine combination is a suitable type design for extended-range operation, should apply to the applicable type certificate holding aeroplane certification authority. An operator should apply similarly, except through Civil Aviation Authority of New Zealand (CAA). The CAA will then initiate an assessment of the airframe-engine combination in accordance with Paragraphs 5 and 6 and Appendix 1 of this Advisory Circular.

5.2 Criteria

The applicant should conduct an evaluation of failures and failure combinations based on engineering and operational consideration as well as acceptable fail-safe methodology. The analysis should consider effects of operations with a single engine, including allowance for additional stress that could result from failure of the first engine. Unless it can be shown that equivalent safety levels are provided or the effects of failure are minor, failure and reliability analysis should be used as guidance in verifying that the proper level of fail-safe design has been provided. The following criteria are applicable to the extended-range operation of aeroplanes with two engines:

- (a) Airframe systems should be shown to comply with Section 25.1309, of the Federal Aviation Rules, Amendment 25-41, or equivalent.
- (b) The propulsion systems should be shown to comply with Section 25.901, of the Federal Aviation Rules, Amendment 25-40, or equivalent as follows—
 - (1) Engineering and operational judgement applied in accordance with the guidance outlined in Appendix 1 should be used to show that the propulsion system can achieve the desired level of reliability. This determination of the propulsion system reliability is derived from a world-fleet database containing all IFSD events, all significant engine reliability problems and available data on cases of significant loss of thrust, including those where the engine failed or was throttled-back/shut down by the pilot.

- (2) This determination should take due account of the approved maximum diversion time and rectification of identified engine design problems, as well as events where in-flight starting capability may be degraded.
 - (3) Contained engine failure, cascading failures, consequential damage or failure of remaining systems or equipment should be assessed in accordance with Section 25.901 of the FARs (or equivalent).
 - (4) In addition to the flight crew fuel management discussed in Paragraph 7.5.2.(b).(7) a means should be provided to alert the flight crew of the low-fuel quantity condition. The alert should commence at a total fuel quantity available condition equivalent to no less than one-half hour operation at maximum continuous power.
 - (5) It should be shown during type design evaluation that adequate engine limit margins exist (i.e. rotor speed, exhaust gas temperatures) for conducting extended duration single-engine operation during the diversion at all approved power levels and in all expected environmental conditions. This assessment should account for the effects of additional engine loading demands (e.g. anti-ice, electrical, etc), which may be necessary during the single-engine flight phase associated with the diversion. (Reference Appendix 4, Paragraph 2.8)).
- (c) The safety impact of an uncontained engine failure should be assessed in accordance with Sections 25.903, 33.19 and 33.75 of the FAR.
 - (d) The APU installation, if required for extended-range operations, should meet the applicable Part 25 provisions (Subpart E – Powerplant Provisions, through Amendment 25-46 (or equivalent)) and any additional requirements necessary to demonstrate its ability to perform the intended function as specified by the Federal Aviation Administration following a review of the applicant’s data. If a certain extended-range operation may necessitate in-flight start and run of the APU, it must be substantiated that the APU has adequate reliability for that operation.
 - (e) Extended duration, single-engine operation should not require exceptional piloting skills and/or crew co-ordination. Considering the degradation of the performance of the aeroplane type with a single-engine inoperative, the increased flight crew workload and the malfunction of remaining systems and equipment, the impact on flight crew procedures should be minimised. Aeroplanes with a Flight Management System should provide all required information on the appropriate CDU page i.e. engine-out descent and cruise. Consideration should also be given to the effect of continued flight with an engine and/or airframe system inoperative on the flight crew and passengers’ physiological needs (for example, temperature control).
 - (f) It should be demonstrated for extended duration single-engine operation, that the remaining power (electrical, hydraulic, pneumatic) will continue to be available at levels necessary to permit continued safe flight and landing and to provide those services necessary for the overall safety of the passengers and crew. Unless it can be shown that cabin pressure can be maintained on single-engine operation at the altitude necessary for continued flight to a suitable aerodrome, oxygen must be available to sustain the passengers and crew for the maximum diversion time.
 - (g) In the event of any single failure, or any combination of failures not shown to be extremely improbable, it should be shown that electrical power is provided for essential flight instruments, warning systems, avionics, communications, navigation, required route or destination guidance equipment, supporting systems and/or hardware and any other equipment deemed necessary for extended-range operations to continue safe flight and a landing at a suitable aerodrome. Information provided to each pilot should be of sufficient accuracy for the intended operation.

- (h) Three or more reliable, independent alternating current (AC) electrical power sources should be available. As a minimum, each electrical source should be capable of powering the items specified in Paragraphs 5.3.5 and 5.3.7. If one or more of the required electrical power sources are provided by an APU, hydraulic system, or ram air turbine, the following criteria apply as appropriate:
 - (1) The APU when installed should meet the criteria in Paragraph 5.2.(d) .
 - (2) The hydraulic power source should be reliable. To achieve this reliability, it may be necessary to provide two or more independent energy sources (e.g. bleed air from two or more pneumatic sources).
 - (3) Ram air turbine (RAT) deployment should be demonstrated to be sufficiently reliable in deployment and use. The RAT should not require engine dependent power for deployment.
- (i) It should be shown that adequate status monitoring information and procedures on all critical systems are available for the flight crew to make pre-flight, in-flight go/no-go and diversion decisions.
- (j) Extended-range operations are not permitted with time-related cargo fire limitations less than the approved maximum diversion time in still air conditions (including an allowance for 15 minutes holding and an approach and landing) determined by considering other relevant failures, such as an engine inoperative and combinations of failures not shown to be extremely improbable.
- (k) Airframe and propulsion ice protection should be shown to provide adequate capability (aeroplane controllability, etc) for the extended operation. This should account for prolonged exposure to lower altitudes associated with the engine-out diversion, cruise, holding, approach and landing.
- (l) Although a hardware/design solution to a problem is preferred, if scheduled maintenance, replacement and/or inspection are utilised to obtain type design approval for extended-range operation, then the specific maintenance information should be easily retrievable and clearly referenced and identified in an appropriate maintenance document.

5.3 Analysis of failure effects and reliability

5.3.1 General

The analysis and demonstration of airframe and propulsion system failure effects and reliability provided by the applicant should be based on in service experience as required by Section 6 and the expected longest diversion time for extended-range routes likely to be flown with the aeroplane. If it is necessary in certain failure scenarios to consider less time due to time-limited systems, the next lower time of 75 or 120 minutes will be established as the approved diversion time.

5.3.2 Propulsion systems

- (a) An assessment of the propulsion systems reliability for particular airframe-engine combinations should be made in accordance with Appendix 1.
- (b) The analysis should consider:
 - (1) Effects of operation with a single-propulsion system (i.e. high-power demands, bleed air requirements, etc) and include probable damage that could result from failure of the first engine.

- (2) Effects of the availability and management of fuel for propulsion system operation (i.e. cross-feed valve failures, fuel mismanagement, ability to distinguish and isolate leaks, etc)
- (3) Effects of other failures, external conditions, maintenance and crew errors that could jeopardise the operation of the remaining propulsion system should be examined.
- (4) Effect of inadvertent thrust-reverser deployment, if not shown to be extremely improbable (includes design and maintenance).

5.3.3 Hydraulic power and flight control

Consideration of these systems may be combined, since many commercial aeroplanes have full hydraulically powered controls. For aeroplanes with all flight controls being hydraulically powered, evaluation of hydraulic system redundancy should show that single failures or failure combinations not shown to be extremely improbable do not preclude continued safe flight and landing at a suitable aerodrome. As part of this evaluation, the loss of any two hydraulic systems and any engine should be assumed to occur unless it is established during failure evaluation that there are no sources of damage or the location of the damage source are such that this failure condition will not occur.

5.3.4 Electrical power

Electric power is provided to a small group of instruments and devices required for continued safe flight and landing, and to a much larger group of instruments and devices needed to allow the flight crew to cope effectively with adverse operating condition. Multiple source (engine driven generators, APU's etc.) should be provided to meet both the "continued safe flight and landing requirements" and the "adverse conditions requirements" as amplified in FAA AC 25.1309-1A. A review should be conducted of fail-safe and redundancy features supported by a statistical analysis considering exposure times established in Paragraph 5.3.1

5.3.5 Equipment cooling

The data should establish that the necessary electronic equipment for extended-range operation has the ability to operate acceptably considering failure modes in the cooling system not shown to be extremely improbable. Adequate indication of the proper functioning of the cooling system should be demonstrated to ensure system operation prior to dispatch and during flight.

5.3.6 Cargo compartment

The cargo compartment design and fire protection system capability (if necessary) should be consistent with the following:

- (a) **Design:** The cargo compartment fire protection system integrity and reliability should be suitable for the intended operation considering fire detection sensors, liner materials, etc.
- (b) **Fire protection:** An analysis or tests should be conducted to show, considering approved maximum diversion in still air (including an allowance for 15-minute holding and/or approach and landing), that the ability of the system to suppress or extinguish fires is adequate to ensure safe flight and landing at a suitable aerodrome.

5.3.7 Communications, Navigation, and basic flight instruments

(Altitude, airspeed, attitude and heading)

It should be shown that, under all combinations of propulsion and/or airframe system failures which are not extremely improbable, reliable communication, sufficiently accurate

navigation, basic flight instruments, and any route and destination guidance needed to comply with contingency procedures for intended operation will be available to each pilot.

5.3.8 Cabin pressurisation

A review of fail-safe and redundancy features should show that the loss of cabin pressure is improbable under single-engine operating conditions. Approved aeroplane performance data should be available to verify the ability to continue safe flight and landing after loss of pressure and subsequent operation at a lower altitude.

5.3.9 Cockpit and cabin environment

It should be shown that an adequate cockpit and cabin environment is preserved following all combinations of propulsion and electrical system failures, which are not shown to be extremely improbable

5.4 Assessment of failure conditions

In assessing the fail-safe features and effects of failure conditions, account should be taken of:

- (a) The variations in the performance of the system, the probability of the failure(s), the complexity of the crew action, and the type and frequency of the relevant crew training.
- (b) Factors alleviating or aggravating the direct effects of the initial failure condition, including consequential or related conditions existing within the aeroplane which may affect the ability of the crew to deal with direct effects, such as the presence of smoke, aeroplane accelerations, interruption of air-to-ground communication, cabin pressurisation problems, etc.
- (c) A flight test should be conducted by the manufacturer and witnessed by the type certification authority to validate expected aeroplane flying qualities and performance considering engine failure, electrical power losses, etc. The adequacy of remaining aeroplane systems and performance and flight crew ability to deal with the emergency considering remaining flight deck information will be assessed in all phases of flight and anticipated operating conditions. Depending on the scope, content, and review, by the responsible Aeroplane Certification Authority, of the manufacturer's data base, this flight test could be used as a means for approving the basic aerodynamic and engine performance data used to establish the aeroplane performance identified in Paragraph 7.4.4.(e).

5.5 Certification authority aeroplane assessment report

The assessment of the reliability of propulsion and airframe systems for a particular airframe-engine combination will be contained in a Certification Authority Aeroplane Assessment Report. Following approval of the report, the propulsion and airframe system recommendations will be included in Certification Authority approved documents that establishes the CMP standard requirements for the candidate aeroplane and the Aeroplane Flight Manual.

5.6 ETOPS type design approval

Upon satisfactory completion of the aeroplane evaluation through an engineering inspection and test programme consistent with the type certification procedures of FAR Part 21, or their equivalent, and sufficient in-service experience data:

The type design approval will be reflected in the Certification Authority approval AFM or supplement, the Type Certification Data Sheet or Supplemental Type Certificate, which contains directly or by reference the following pertinent information, as applicable:

- (a) Special limitations (if necessary), including any limitations associated with a maximum diversion time established in accordance with Paragraph 5.3
- (b) Markings or placards (if required);
- (c) Revision to the performance section in accordance with paragraph 7.4.4.(e);
- (d) The airborne equipment, installation, and flight crew procedures required for extended-range operations;
- (e) Description or reference to a document containing the approved aeroplane configuration CMP standard;
- (f) A statement to the effect that:

“The type design reliability and performance of this airframe-engine combination has been evaluated in accordance with Advisory Circular and found suitable for (state maximum diversion time) extended-range operations with the incorporation of the approved aeroplane configuration CMP standard. This finding does not constitute approval to conduct extended-range operations”.

5.7 Type design change process

The Certification Authority responsible for the certification of the type design will include the consideration of extended-range operation in its normal monitoring and design change approval functions. Any significant problems, which adversely effect extended-range operation, will be corrected. Modifications or maintenance actions to achieve or maintain the reliability objective of extended-range operations will be incorporated into the type design CMP standard document. The Certification Authority will normally co-ordinate this section with the affected industry. The Airworthiness Directive process will be utilised as necessary to effect a CMP standard change. The current CMP standard will be reflected in each ETOPS operator’s operations specifications.

5.8 Continued airworthiness

The type design CMP standard that establishes the suitability of an aeroplane for extended-range operations defines the minimum standards for the operation. Incorporation of additional modifications or maintenance actions generated by an operator or manufacturer to enhance or maintain the continued airworthiness of the aeroplane may be made through the normal approval process. The operator or manufacturer (as appropriate) should thoroughly evaluate such changes to ensure that they do not adversely effect reliability or conflict with requirements for extended-range approval.

6. In-Service Experience

6.0 Propulsion system reliability

In establishing the suitability of a type design in accordance with Section 5 of this Advisory Circular and as a prerequisite to obtaining any operational approval, in accordance with the criteria of Section 7 of this Advisory Circular, it should be shown that an acceptable level of propulsion system reliability has been achieved in service by the world fleet for that particular airframe-engine combination. The candidate operator needs also to obtain sufficient maintenance and operation familiarity with the particular airframe-engine combination in question.

6.1 IFSD rate & airframe system reliability

Prior to the type design approval, Section 5, it should be shown that the world fleet of the particular airframe-engine, combination for which approval is sought can or has achieved, as determined by the Certification Authority (see Appendix 1), an acceptable and reasonably stable level of single propulsion system in-flight shutdown (IFSD) rate and airframe system reliability. Engineering and operational judgment applied in accordance with the guidance outline in Appendix 1 will then be used to determine that the IFSD rate objective for all independent causes can be achieved. This assessment is an integral part of the determination in Paragraph 5.2.(b) for type design approval from a world fleet database containing all in-flight shutdown events and significant engine reliability problems, in accordance with requirements of Appendix 1. This determination will take due account of the approved maximum diversion time, rectification of identified system problems, as well as events where in-flight starting capability may be degraded.

6.2 Operational in-service experience

Each operator requesting approval to conduct extended-range operations should have operational in-service experience appropriate to the operation proposed. Sub-paragraphs 6.2.1, 6.2.2, 6.2.3 contain guidelines for requisite in service experience. These guidelines may be reduced or increased following review and concurrence on a case-by-case basis by the Director. Any reduction or increase in service experience guidelines will be based on an evaluation of the operator's ability and competence to achieve the necessary reliability for the particular airframe-engine combination in extended-range operations. For example, a reduction in service experience may be considered for an operator who can show extensive in service experience with a related engine on another aeroplane, which has achieved acceptable reliability. In contrast, an increase in service experience may be considered for those cases where heavy maintenance has yet to occur and/or abnormally low number of take-offs have occurred.

6.2.1 75-minute Operation:

Consideration may be given to the approval of 75-minute extended-range operations for operators with minimal or no in service experience with the airframe-engine combination. This determination considers such factors as the proposed area of operations, the operator's demonstrated ability to successfully introduce aeroplanes into operations, and the quality of the proposed maintenance and operations programmes.

6.2.2. 120-Minute Operation:

Each operator requesting approval to conduct extended-range operations with a maximum diversion time of 120 minutes (in still air) should have 12 consecutive months of operational in-service experience with the specified airframe-engine combination. In-service experience guidelines may be increased or decreased by the Director, as noted in Paragraph 6.2.

6.2.3 180-Minute Operation

Each operator requesting approval to conduct extended-range operations with a maximum diversion time of 180 minutes (in still air) should have previously gained 12 consecutive months of operational in service experience with the specified airframe-engine combination in conducting 120-minute extended-range operations. In service experience guidelines may be reduced or increased by the Director, as noted in Paragraph 6.2. Likewise, the substitution of in-service experience which is equivalent to the actual conduct of 120-minute ETOPS operations will also be established by the Director, on a case-by-case basis.

7. Operational Approval Considerations

7.0 General

Paragraphs 7.1 through 7.8 detail the criteria for operational approval of extended-range operations with a maximum diversion time of 120 minutes to an en route alternative (at single-engine inoperative cruise speed in still air). Appendices 4 and 5 serve two functions; first, they provide expanded explanation of the elements contained in this Advisory Circular and second, they serve to differentiate the criteria for approval of operations less than 120 minutes (75 minutes) and beyond 120 minutes (180 minutes). For approval of 75-minute operation, only certain requirements of this Advisory Circular apply. (See Appendix 5.)

7.1 Requesting approval

Any operator requesting approval for extended-range operations with two-engine aeroplane (after providing an acceptable evaluation of the considerations in Sections 8 and 9) should submit the requests, with the required supporting data, to the Director of Civil Aviation at least 90 days prior to the proposed start of extended-range operation with the specific airframe-engine combination. In considering an application from an operator to conduct extended-range operations, an assessment should be made of the operator's overall safety record, past performance, flight crew training and maintenance programmes. The data provided with the request should substantiate the operator's ability and competence to safely conduct and support these operations and should include the means used to satisfy the considerations outlined in this paragraph. (Any reliability assessment obtained, either through analysis or service experience, should be used as guidance in support of operational judgments regarding the suitability of the intended operation.)

7.2 Assessment of the operator's propulsion system reliability

Following the accumulation of adequate operating experience by the world fleet of the specified airframe-engine combination and the establishment of an IFSD rate objective in accordance with Appendix 1 for use in ensuring the propulsion system reliability necessary for extended-range operations, an assessment should be made of the applicant's ability to achieve and maintain this level of propulsion system reliability. This assessment should include trend comparisons of the operator's data with other operators as well as the world fleet average values and the application of a qualitative judgment that considers all of the relevant factors. The operator's past record of propulsion system reliability with related types of power units should also be reviewed, as well as its record of achieved systems reliability with the airframe-engine combination for which authorisation is sought to conduct extended-range operations.

7.3 Engineering modifications and maintenance programme considerations

Although these considerations are normally part of the operator's continuing airworthiness programme, the maintenance and reliability programme may need to be supplemented in consideration of the special requirements of extended-range operations (Appendix 4). The following items, as part of the operator's programme, will be reviewed to ensure that they are adequate for extended-range operations:

7.3.1 Engineering modifications

The operator should provide to the Director all the titles and numbers of all modifications, additions and changes which were made in order to substantiate the incorporation of the CMP standard in the aeroplanes used in extended-range operation.

7.3.2 Maintenance procedures

Following approval of the changes in the maintenance and training procedures, substantial changes to maintenance and training procedures, practices or limitations established to

qualify for extended-range operations should be submitted to the Director 90 days before such changes may be adopted.

7.3.3 Reliability reporting

The reliability-reporting programme as supplemented and approved, should be implemented prior to and continued after approval of extended-range operation. Data from this process should result in a suitable summary of problem events, reliability trends and corrective actions and be provided regularly to the Director. Appendix 4 contains additional information concerning propulsion and airframe system reliability monitoring and reporting.

7.3.4 Approved modifications and inspections

Approved modifications and inspections that maintain the reliability objectives for the propulsion and airframe systems as a consequence of Airworthiness Directive (AD) actions and revised CMP standards should be promptly implemented. Other recommendations made by the engine and airframe manufacturers should also be considered for prompt implementation. This would apply to both installed and spare parts.

7.3.5 Procedures and centralised control processes

Procedures and centralised control process should be established which would preclude an aeroplane being dispatched for extended-range operation after propulsion system shutdown or primary airframe system failure on a previous flight, or significant adverse trends in the system performance, without appropriate corrective action having been taken. Confirmation of such action as being appropriate, in some cases, may require the successful completion of one or more non revenue or non ETOPS revenue flights (as appropriate) prior to dispatch on an extended-range operation.

7.3.6 Programme continuity

The programme used is to ensure that the airborne equipment will continue to be maintained at the level of performance and reliability necessary for extended-range operation.

7.3.7 Engine condition monitoring programme.

7.3.8 Engine oil consumption monitoring programme.

7.4 Flight dispatch considerations

7.4.1 General

The flight dispatch considerations specified in this section are in addition to, or amplify the requirements contained in the Civil Aviation Rules and specifically apply to extended-range operations. Although many of the considerations in this Advisory Circular are currently incorporated into approved programmes for other aeroplanes or route structures, the unique nature of extended-range operations with two-engine aeroplanes necessitates a re-examination of these operations to ensure that the approved programmes are adequate for this purpose.

7.4.2 Master minimum equipment list (MMEL)

System redundancy levels appropriate to extended-range operations should be reflected in the MMEL. An operator's MMEL may be more restrictive than the MMEL considering the kind of ETOPS operation proposed and equipment and service problems unique to the operator. Systems considered to have a fundamental influence on flight safety may include, but are not limited to the following:

- (a) Electrical, including battery;
- (b) Hydraulic;

- (c) Pneumatic;
- (d) Flight instrumentation;
- (e) Fuel;
- (f) Flight control;
- (g) Ice protection;
- (h) Engine start and ignition;
- (i) Propulsion system instruments;
- (j) Navigation and communications;
- (k) Auxiliary power-units;
- (l) Air conditioning and pressurisation;
- (m) Cargo fire suppression;
- (n) Emergency equipment; and
- (o) Any other equipment necessary for extended-range operations.

7.4.3 Communication and navigation facilities

An aeroplane should not be dispatched on an extended-range operation unless:

- (a) Communications Facilities are available to provide under normal conditions of propagation at the normal one-engine inoperative cruise altitudes, reliable two-way voice communications between the aeroplane and the appropriate air traffic control unit over the planned route of flight and the routes to any suitable alternate to be used in the event of diversion;
- (b) Non-visual ground navigation aids are available and located so as to provide, taking account of the navigation equipment installed in the aeroplane, the navigation accuracy necessary for the planned route and altitude of flight and the routes to any alternate and altitudes to be used in the event of an engine shutdown; and
- (c) Visual and non-visual aids are available at the specified alternates for the authorised types of approaches and operation minima.

7.4.4 Fuel and oil supply

- (a) **General** — An aeroplane should not be dispatched on an extended-range operation unless it carries sufficient fuel and oil to meet the requirements of the Civil Aviation Rules, plus any additional fuel that may be determined in accordance with subparagraph 7.4.4.(b). In computing fuel requirements, advantage may be taken of drift down and at least the following should be considered as applicable:
 - (1) Current forecast winds and meteorological conditions along the expected flight path at the one-engine inoperative cruising altitude and throughout the approach and landing;
 - (2) Any necessary operation of ice protection systems and performance loss due to ice accretion on the unprotected surfaces of the aeroplane;
 - (3) Any necessary operation of auxiliary power units;

- (4) Loss of aeroplane pressurisation and air conditioning; consideration should be given to flying at an altitude meeting oxygen requirements Part 91 in the event of loss of pressurisation;
 - (5) An approach followed by a missed approach and a subsequent approach and landing;
 - (6) Navigation accuracy necessary; and
 - (7) Any known Air Traffic Control (ATC) constraints.
- (b) **Critical fuel reserves** — In establishing the critical fuel reserves, the applicant is to determine the fuel necessary to fly to the most critical point and execute a diversion to a suitable alternate under the conditions outlined in subparagraph 7.4.4.(c) – the Critical Fuel Scenario. These critical fuel reserves should be compared to the normal Civil Aviation Rule requirements for the flight. If it is determined by this comparison that the fuel to complete the critical fuel scenario exceeds the fuel that would be on board at the most critical point, as determined by Civil Aviation Rules, additional fuel should be included to the extent necessary to safely complete the critical Fuel scenario. In consideration of the items listed in subparagraph 7.4.4(a), the critical fuel scenario should allow for: a contingency figure of 5 percent added to the calculated fuel burn from the critical point to allow for errors in wind forecasts, a 5 percent penalty in fuel mileage**, any Configuration Deviation List items, both airframe and engine anti-icing; and account for ice accumulation on unprotected surfaces if icing conditions are likely to be encountered during the diversion. If the APU is a required power source, then its fuel consumption should be accounted for during the appropriate phase(s) of flight. (**In lieu of an applicant’s established value for in service deterioration in cruise fuel mileage.)
- (c) **Critical fuel scenario** — The following describes a scenario for a diversion at the most critical point. The applicant should confirm the scenario to be used in determining the critical fuel necessary is operationally the most critical considering both the time and aeroplane configuration (e.g. 2 engine versus 1 engine at 10,000 feet, non standard aeroplane configuration not shown to be extremely improbable, paragraph 5.3.2.(b).(4).
- (1) At the critical point, consider simultaneous failure of an engine and the pressurisation system (critical point based on time to a suitable alternate at the approved one-engine inoperative cruise speed).
 - (2) Immediate descent to and continued cruise at 10,000 feet at the approved one-engine inoperative cruise speed or continued cruise above 10,000 feet if the aeroplane is equipped with sufficient supplemental oxygen in accordance with Part 91.
 - (3) Upon approaching destination, descent to 1,500 feet above destination, hold for 15 minutes, initiation of an approach followed by a missed approach and then execution of a normal approach and landing.
- (d) **Alternate aerodromes** — An aeroplane should not be dispatched on an extended-range operation unless the required take-off, destination and alternate aerodrome, including suitable en route alternate aerodromes to be used in the event of engine shutdown or aeroplane system failure(s) which require a diversion, are listed in the cockpit documentation (e.g. computerised flight plan). Suitable en route alternates should also be identified and listed in the dispatch release for all cases where the planned flight route flight contains a point more than one hour flying time at the one-engine inoperative speed from an adequate aerodrome. Since these suitable en route alternates serve a different purpose than the destination alternate aerodrome and would normally

be used only in the event of an engine failure or the loss of primary aeroplane systems, an aerodrome should not be listed as a suitable en route alternate unless:

- (1) The landing distances required as specified in the AFM for the altitude of the aerodrome, for the runway expected to be used, taking into account wind conditions, runway surface conditions and aeroplane handling characteristics, permit the aeroplane to be stopped within the landing distance available as declared by the aerodrome authorities and computed in accordance with Part 121
 - (2) The aerodrome services and facilities are adequate for the applicant operator's approved approach procedure(s) and operating minima for the runway expected to be used; and
 - (3) The latest available forecast weather conditions for a period commencing one hour before the established earliest time of landing and ending one hour after the established latest time of landing at the aerodrome, equals or exceeds the authorised weather minima for en route alternate aerodromes in Appendix 3. In addition, for the period commencing one hour before the established earliest time of landing and ending one hour after the established latest time of landing at the aerodrome, the forecast cross-wind component, including gusts, for the landing runway expected to be used should be less than the maximum permitted cross-wind for landing.
 - (4) During the course of the flight, the flight crew should be informed of any significant changes in conditions at designated en route alternates. Prior to a 120-minute extended-range flight proceeding beyond the extended-range entry point, the forecast weather for the time periods established in subparagraph 7.4.4 (d)(3), landing distances and aerodrome services and facilities at designated en route alternates should be evaluated. If any conditions are identified (such as weather forecast below landing minima) which would preclude safe approach and landing, then the pilot should be notified and an acceptable alternate(s) selected where safe approach and landing can be made.
- (e) **Aeroplane performance data** — No aeroplane should be dispatched on an extended-range flight unless the operator's Operations Manual contains sufficient data to support the critical fuel reserve and area of operations calculation. The following data should be based on Civil Aviation Rule requirements (see Paragraph 5.4.(c)) information provided or referenced in the Aeroplane Flight Manual:
- (1) Detailed one-engine inoperative performance data including fuel flow for standard and non-standard atmospheric conditions and as a function of airspeed and power setting, where appropriate, covering:
 - (i) Drift down (includes net performance);
 - (ii) Cruise altitude coverage including 10,000 feet;
 - (iii) Holding;
 - (iv) Altitude capability (includes net performance); and
 - (v) Missed approach.
 - (2) Detailed all-engine-operating performance data, including nominal fuel flow data, for standard and non-standard atmospheric conditions and as a function of airspeed and power setting, where appropriate, covering:
 - (i) Cruise (altitude coverage including 10,000 feet); and

- (ii) Holding
- (3) Details of any other conditions relevant to extended-range operations which can cause significant deterioration of performance, such as ice accumulation on the unprotected surfaces of the aeroplane, RAM Air Turbine (RAT) deployment, thrust reverser deployment, etc.
- (4) The altitudes, airspeeds, thrust settings and fuel flow used in establishing the ETOPS area of operations for each airframe-engine combination must be used in showing the corresponding terrain and obstruction clearances in accordance with Civil Aviation Rules

7.5 Flight crew training, evaluation and operating manuals

7.5.1 Adequacy of flight crew training and operating manuals

The CAA will review in-service experience of critical and essential aeroplane systems. The review will include system reliability levels and individual event circumstances, including crew actions taken in response to equipment failure or unavailability. The purpose of the review will be to verify the adequacy of information provided in training programmes and operating manuals. The aviation industry should provide information for and participate in these reviews. The CAA will use the information resulting from these reviews to modify or update flight crew training programmes, operating manuals and checklists, as necessary.

7.5.2 Flight crew training and evaluation programme

The operator's training programme in respect to extended-range operations should provide training for flight crew members followed by subsequent evaluations and proficiency checks in the following areas:

- (a) Performance
 - (1) Flight planning, including all contingencies.
 - (2) Flight performance progress monitoring.
- (b) Procedures
 - (1) Diversion procedures.
 - (2) Use of appropriate navigation and communication systems.
 - (3) Abnormal and emergency procedures to be followed in the event of foreseeable failures, including:
 - (i) Procedures for single and multiple failures in flight that would precipitate go/no-go and diversion decisions.
 - (ii) Operational restrictions associated with these failures including any applicable MEL considerations.
 - (iii) Procedures for air start of the propulsion systems, including the APU, if required.
 - (iv) Crew incapacitation.
 - (4) Use of emergency equipment including protective breathing and ditching equipment.
 - (5) Procedures to be followed in the event that there is a change in conditions at designated en route alternates that would preclude safe approach and landing.

- (6) Understanding and effective use of approved additional or modified equipment required for extended-range operations.
- (7) Fuel Management — Flight crew should be trained on the fuel management procedures to be followed during the en route portion of the flight. These procedures should provide for an independent cross-check of fuel quantity indicators. For example, fuel flows could be used to calculate fuel burned and compared to indicated fuel remaining.

7.5.3 ETOPS check captain

The operator should designate specific ETOPS Check-Captains. The objective of the ETOPS Check-Captain programme should be to ensure standardised flight crew practices and procedures and also to emphasise the special nature of ETOPS operations. Only Captains with a demonstrated understanding of the unique requirements of ETOPS should be designated as a Check-Captain.

7.6 Operational limitations

7.6.1 Area of operation

- (a) An operator may be authorised to conduct extended-range operations within an area where the diversion time at any point along the proposed route of flight to an adequate aerodrome is 75, 120 or 180 minutes at the approved one-engine cruise speed (under standard conditions in still air). Appendices 1, 4 and 5 provide criteria for operation at the different diversion times.
- (b) The area which meets the considerations in Paragraph 7.6.1.(a) may be approved for extended-range operations with two-engine aeroplanes and should be specified in the operations specifications as the authorised area of operations.

7.6.2 Flight dispatch limitation

The flight dispatch limitation should specify the maximum diversion time from a suitable aerodrome an operator can conduct a particular extended-range operation. The maximum diversion time at the approved one-engine inoperative cruise speed (under standard conditions in still air) should not be any greater than the value established by subparagraph 7.6.1(a).

- (a) **Use of maximum diversion time** — The flight dispatch considerations should ensure that extended-range operation is limited to flight plan routes where the approved maximum diversion time to suitable aerodromes can be met. Operators should provide for:
 - (1) Compliance with Civil Aviation Rules where, upon occurrence of an in-flight shutdown of an engine, the pilot should promptly initiate diversion to fly to and land at the nearest aerodrome, in point of time, determined to be suitable by the flight crew.
 - (2) A practice to be established such that in the event of a single or multiple primary system failure, the pilot will initiate the diversion procedure to fly and land at the nearest suitable aerodrome, unless it has been demonstrated that no substantial degradation of safety results from continuation of the planned flight
- (b) **Criteria for maximum diversion times** — The criteria for different maximum diversion times are detailed in Appendices 1, 4 and 5.

7.6.3 Contingency procedures

Contingency procedures should not be interpreted in anyway which prejudices the final authority and responsibility of the pilot in command for the safe operation of the aeroplane.

7.7 Operations specifications

7.7.1 Approvals

An operator's two-engine aeroplane should not be operated on an extended-range flight unless authorised by operations specifications approval (both maintenance and operations).

7.7.2. Operations specifications for ETOPS

Operations specifications for ETOPS extended-range operations should specifically include provisions covering at least the following:

- (a) Define the particular airframe-engine combinations, including the current approved CMP standard required for extended-range operation as normally identified in the AFM (paragraph 5.6.).
- (b) Authorised area of operation.
- (c) Minimum altitudes to be flown along the planned and diversionary routes.
- (d) The maximum diversion time, at the approved one-engine inoperative cruise speed (under standard conditions in still air), that any point on the route the aeroplane may be from a suitable aerodrome for landing.
- (e) Aerodromes authorised for use, including alternates and associated instrument approaches and operating minima.
- (f) The approved maintenance and reliability programme (ref. Appendix 4) for extended-range operations including those items specified in the type design approved CMP standard.
- (g) Identification of those aeroplanes designated for extended-range operation by make and model as well as serial and registration.
- (h) Aeroplane Performance Reference.

7.8 Operational validation flight

7.8.1 Conditions for validation flight

The operator should demonstrate, by means of a CAA witnessed validation flight using the specified airframe-engine combination, that it has the competence and capability to safely conduct and adequately support the intended operation. (This is in addition to the flight test required for type design approval in Paragraph 5.4.(c)) The Director, will determine the conditions for each operator's validation flight following a review on a case-by-case basis of the operator's experience and the proposed operation.

7.8.2 Emergency conditions

The following emergency conditions should be demonstrated during the validation flight unless the CAA has witnessed successful demonstration of these conditions, in an acceptable simulation, prior to the validation flight:

- (a) Total loss of thrust of one-engine; and total loss of engine-generated electrical power;
or
- (b) Any other condition considered to be more critical in terms of airworthiness, crew workload or performance risk.

7.9 Extended-range operations approval

Following a type design approval for extended-range operations in accordance with Section 5 and satisfactory application of the criteria in Sections 6 and 7 and prior to the issuance of

operations specifications, the operator's application, as well as the designated Airline Inspectors' recommendations and supporting data should be forwarded to the Director, for review and concurrence. Following the review and concurrence by the Director, the operational validation flight should be conducted in accordance with any additional guidance specified in the review and concurrence. When the operational validation flight has been evaluated and found acceptable, an applicant may be authorised to conduct extended-range operations with the specified airframe-engine combination. Approval to conduct ETOPS is made by the issuance of operations specifications amendment containing appropriate limitations.

8. Continuing Surveillance

8.1 General

The fleet average IFSD rate for the specified airframe-engine combination will continue to be monitored in accordance with Appendices 1 and 4. As with all other operations, Civil Aviation will also monitor all aspects of the extended-range operations it has authorised to ensure that the levels of reliability achieved in extended-range operation remain at the necessary levels as provided in Appendix 1, and that the operation continues to be conducted safely. In the event that an acceptable level of reliability is not maintained, significant adverse trends exist, or if significant deficiencies are detected in the type design or the conduct of the ETOPS operation, Civil Aviation will initiate a special evaluation, impose operational restriction, if necessary and stipulate corrective action for the operator to adopt to resolve the problem in a timely manner.

Appendix 1 — Propulsion System Reliability Assessment

1 Assessment Process

In order to establish if a particular airframe-engine combination has satisfied the current propulsion system reliability requirements for extended-range operations, thorough assessment will be conducted by a group of the **Basic Certification Authority Specialists**, (BCAS) and in the USA the **Propulsion System Reliability Assessment Board** (PSRAB) utilising all the pertinent propulsion system data and information available (includes the APU, if required). Engineering and operational judgment supported by the relevant statistics will be used to determine current propulsion system reliability. The findings of the specialist group will be included in the Certification Authority's Aeroplane Assessment Report.

1.1 Service experience

To provide a reasonable indication of aeroplane propulsion system reliability trends and to reveal problem areas, a certain amount of service experience will be required. In general, extended-range airframe-engine combination reliability assessment concern two major categories; those supporting up to 120 minutes maximum diversion time operations and those support operations beyond 120 minutes maximum diversion times. A special case-by-case operational approval may be granted for 75-minute diversion routes and require limited evaluation of service experience at the time of the application.

(a) Operations up to 120 minutes:

Normally, accumulation of at least 250,000 engine hours in the world fleet will be necessary before the assessment process can produce meaningful results. This number of hours may be reduced if adequate compensating factors are identified which give a reasonable equivalent database as established by the PSRAB or the BCAS. Where experience on another aeroplane is applicable to a candidate aeroplane, a significant portion of the 250,000-hour experience should normally be obtained by the candidate aeroplane. In the event that a particular engine is derived from an existing engine, the required operational experience is subject to establishing the degree of hardware commonalty and operating similarities.

(b) Operations beyond 120 minutes (180 minutes):

Suitability to operate the aeroplane beyond 120 minutes will not be considered until operational experience in 120 minutes extended-range service clearly indicates further credit is appropriate. This would generally include at least one year of service experience with an ETOPS configured fleet at 120-minute operation with a corresponding high level of demonstrated propulsion system reliability.

(c) 75-minute operation authorisation:

In this category service experience of the airframe-engine combination may be less than the 250,000 hours as provided in subparagraph 1.1.(a) It must be shown that sufficient favourable experience has been accumulated, demonstrating a level of reliability appropriate for 75-minutes extended-range operation. As detailed earlier in the Advisory Circular, a particular operator may receive a special 75-minute authorisation following review on a case-by-case basis by the Director.

1.2 Reliability data base

To adequately assess propulsion system reliability, consideration of the proposed maximum diversion time, for extended-range type design approval, certain world-fleet data and information are required. The PSRAB intends to maximise the use of existing sources and

kinds of data generally available; however, additional data may be required in certain cases. In support of applications for extended-range type design approval, data should be provided from various sources to ensure completeness; i.e. engine manufacturer, operator and aeroplane manufacturer. Data so provided should include all event descriptions, qualifications and any pertinent details necessary to help determine the impact on propulsion system reliability. This data should include:

- (a) A list of all engine shutdown events both ground and in flight for all causes (excluding normal training events) including flame-out. The list should provide identification (engine and aeroplane model and serial number and registration), engine configuration and modification history, engine position, circumstances leading up to the event, phase of flight or ground operation weather/environmental conditions and reason for shutdown. In addition information should be provided for all occurrences where control or desired thrust level was not attained.
- (b) Unscheduled engine removal rate (accumulated 6 and 12 months), removal summary, time history of removal rate and primary causes for unscheduled engine removal.
- (c) Dispatch delays, cancellations, aborted take-offs (including those induced by maintenance or crew error) and en route diversions chargeable to the propulsion system
- (d) Total engine hours and cycles and engine hour population (age distribution).
- (e) Mean time between failure of propulsion system components that affect reliability.
- (f) IFSD rate based on a 6- and 12-month rolling average
- (g) Additional data as specified by the PSRAB or the BCAS.

1.3 Risk management and the risk model

- (a) In order to assure that the risk of increased diversion times are acceptable, a risk model has been constructed. The risk model is based upon the known service records of an established large fleet of two-engine civil transport turbo-fan powered aeroplane. The service experience of this “base fleet” has been very satisfactory and reflects a high level of safety in its propulsion systems. It has achieved an average in-flight shutdown rate of approximately .02/1000 hours for a 10-year period while flying predominantly on routes conforming to the requirements of the Basic Certification Authority (i.e. flight paths within 60 minutes flying time from a adequate aerodrome).
- (b) The risk of engine failure during a single-engine diversion event is directly related to the diversion flight time and the propulsion system reliability or IFSD rate. This assumes the failure of the first engine, which causes the diversion, is unrelated to the probability of failure of the second engine during the diversion. Common cause or related failure modes will be discussed in paragraph 2.4. The product of IFSD rate and diversion time can be designated as a risk factor for the diversion and identified as (λT) . For the base fleet of .2/1000 IFSD rate and 60 minutes maximum diversion, (λT) would be $(.02/1000)(60)$. Identifying this base fleet risk factor as $(\lambda T)^*$, other combinations of IFSD rates and diversion times can be ratioed to this base risk factor to determine ETOPS relative risk, $(\lambda T)/(\lambda T)^*$. For ETOPS diversion times of 60 minutes and IFSD rates of .02/1000, the relative risk factor equals 1.0. This relationship is shown in Figure 1.

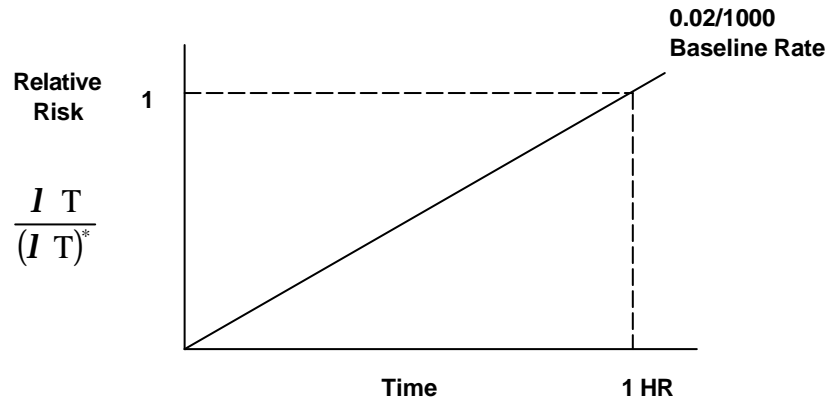


Figure 1

- (c) Extending this model to a family of IFSD rates and diversion times. Figure 2 depicts the relationship between diversion time, IFSD rate and risk relative to the base fleet during the diversion:

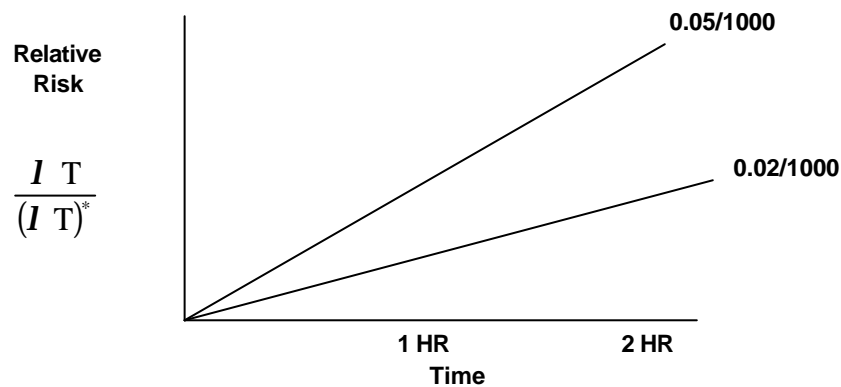


Figure 2

2 Reliability Levels

As discussed in Paragraph 1, in order to ensure that risks associated with increased diversion times are acceptable, reliabilities of ETROPS propulsion systems must be shown to approach or equal those of the highly reliable base fleet of .02/1000 and the appropriate operational and maintenance requirements implemented (see Figure 3).

2.1 Operations up to 120 minutes

The overall fleet reliability should approach or achieve that of the highly reliable base fleet following incorporation of the appropriate configuration maintenance and operational requirements. Propulsion system maturity rates have suggested that incorporation of propulsion system improvements following review of 250,000 hours service experience have yielded an approximate .03/1000 improvement in IFSD reliability. Given the IFSD objective of approximately .02/1000 hours and the potential improvement rate of .03/1000 hours, the extended-range operation start threshold can be established at approximately .05/1000 hours (see Figure 3). It should be noted that this threshold and specific circumstances in fleet reliability data such as confidence in problem resolution, types of failures, etc., could be relevant in establishing a start threshold other than .05/1000.

2.2 Operations beyond 120 minutes

The overall fleet reliability should achieve that of the highly reliable base fleet prior to approval. Only those airframe-engine combinations exhibiting the highest level of overall reliability will be found satisfactory for this type of operation (see Figure 3). In addition, it will normally be a necessary prerequisite for these aeroplanes to have at least one year of satisfactory ETOPS service involving 120 minutes or less operation under conditions of this Advisory Circular.

2.3 Reliability targets-summary

Utilising the risk model, it can be shown that when progressing from the entry level required reliability to the target level reliability (achieved for 180 minutes), the overall risk is not adversely impacted considering respective increase in diversion time. (See Figure 3.)

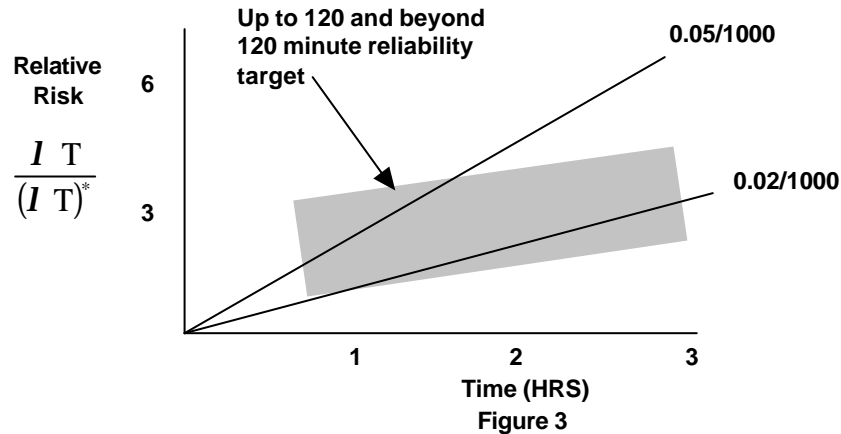


Figure 3

2.4 Risk model corroboration with analysis

As a check of the conservatism for reliability levels identified by the risk model, an analysis can be performed which, given certain assumptions, can corroborate the model targets and identify areas of importance where on-going design, operation and maintenance vigilance must be continued. In the construction of such an analysis, it is assumed that the probability of total thrust loss on any given twin engine aeroplane flight is made up of those engine failure mechanisms which are independent events (e.g. left engine failure independent from right engine failure) and these engine failure events which are related to a common source (e.g. left and right engine fail as a result of a common or related event). This may be shown as:

$$P_{tt} = P_{ti} + P_{tc} \quad (1)$$

P_{tt} = Total probability of complete thrust loss on any given flight.

P_{ti} = Probability of complete thrust loss on flight due to independent causes.

P_{tc} = Probability of complete thrust loss on flight due to common causes.

In determination of the probability of total thrust loss due to independent causes (P_{ti}), International Civil Aviation Organisation Report No. AN-WP/5593 titled "Extended-range Operation of Twin-Engine Commercial Air Transport Aeroplanes." dated February 15, 1984, contains an analytical assessment of in-flight shutdown rate, flight time and diversion time as equated to an observed assessment of commercial transport aeroplane accidents world-wide for a recent several year period.

This relationship, as derived in this study, is shown as:

$$\text{IFSD rate} = \sqrt{\frac{10^{-8} (0.6 + 0.4T)}{T Y}} \quad (2)$$

Where: T = intended duration of flight

Y = diversion time

As an example, for a flight of seven hours and a diversion time of two hours, equation (2) identifies an IFSD of .05/1000 as necessary, while for a diversion time of three hours, .04/1000 is necessary to provide a level of probability supporting the reference world accident rate. As can be seen, the risk model identified in paragraph 1.3. of this Appendix requires an achieved IFSD rate of one half that calculated using the ICAO assessment. It is believed essential that the ETOPS IFSD rate provided by paragraph 1.c. of this Appendix be required considering the influence of common cause failure mechanisms Ptc as well as the uncertainties associated with assumption identified in the ICAO study.

Although there has been no suitable analytical models developed for assessment of the probability of complete thrust loss in flight due to common cause events Ptc, it is considered that by establishment of highly reliable propulsion systems through achievement of low in-flight shutdown rates, continual engine and aeroplane design monitoring for those potential common mode service difficulties and vigilant maintenance and operational practices as identified in Appendices 4 and 5, risks associated with total thrust loss can be maintained at acceptable low levels (Figure 4).

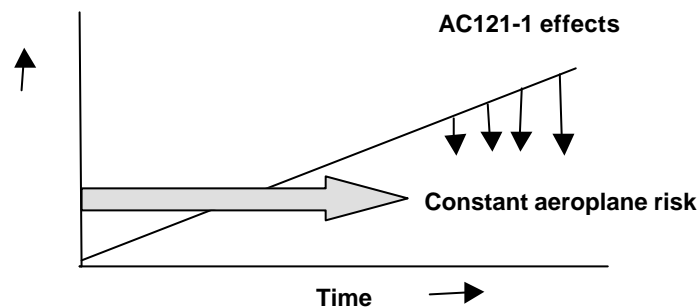


Figure 4

2.5 Propulsion system approval considerations

The determination that a propulsion system is suitable per the assessment considerations of either of the two major categories is provided by the PSRAB or the BCAS. Table 1 identifies the constituent elements of the two major categories of approval considerations.

Table 1**Propulsion System Approval Considerations**

	Up to 120 Minute Operation		Greater Than 120 Minute Operation
•	250,000 engine hours (significant portion with experience candidate aeroplane).	•	same plus at least additional one year with the approved extended-range configured fleet.
•	achieve an IFSD of approximately .05/1000 the objective is continuing improvement towards a rate of .02/1000 hours).	•	achieve and maintain an IFSD of approximately .02/1000 hours.
•	Periodic review of propulsion system data and service experience, and revise the CMP standard as appropriate.	•	same – schedule for incorporation of CMP standards requirements, may be shorter.

3 Engineering Assessment**3.1 Propulsion system reliability methodology**

The methodology to be used by the Certification Authority in determining adequate propulsion system reliability will be a problem-oriented approach using fail-safe concepts, an assessment of the maturity of the propulsion system, the achieved level of IFSD rate, engineering and operational judgement and reliability analysis and will consist of:

3.2 Analysis of failures, defects and malfunctions

An analysis on a case-by-case basis, of all significant failures, defects and malfunctions experienced in service (or during testing) for the airframe-engine combination being addressed. Significant failures are principally those causing or resulting in in-flight shutdown or flame-out of the engine(s), but may also include unusual ground failures, un-commanded thrust reductions and/or unscheduled removal of engines from the aeroplane. In making the assessment, consideration will be given to the following:

- (a) The type of engine, previous experience, similarity in hardware and operating characteristics with other engines and the engine operating rating limit to be used with one-engine shutdown.
- (b) The trends in cumulative and 6 and 12-month rolling average, updated quarterly, of in-flight shutdown rates versus propulsion system flight hours and cycles.
- (c) The effect of corrective modifications, maintenance, etc., on the possible future reliability of the propulsion system
- (d) Maintenance actions recommended and performed and their effect on engine and APU failure rates.
- (e) The accumulation of operational experience which covers the range of environmental limitations likely to be encountered.
- (f) Intended maximum flight duration and approved maximum diversion time.

3.3 Assessment of corrective actions

An assessment of the corrective actions taken for each problem identified with the objective of verifying that the action is sufficient to correct the deficiency.

3.4 PSRAB or the BCAS determination

When each identified significant deficiency has a corresponding Basic Certification Authority-approved corrective action and when all corrective actions are satisfactorily incorporated and verified, the PSRAB or the BCAS determines that an acceptable level of reliability can be achieved. Statistical corroboration will also be utilised. When foreign manufacturer's and/or operator's data are being evaluated, the respective civil airworthiness authorities will be offered the opportunity to participate. They will be briefed by the PSRAB or the BCAS during the proceedings and provided a copy of the final report for their review.

4 PSRAB/BCAS findings

Once an assessment has been completed and the PSRAB or the BCAS have documented their findings, the Basic Certification Authority will declare whether or not the particular airframe-engine combination satisfies the relevant considerations of this Advisory Circular

. Items recommended to qualify the propulsion system, maintenance requirements and limitations will be included in the Aeroplane Assessment Report. (Paragraph 5.5).

5 On-going fleet monitoring

In order to ensure that the desired level of reliability is maintained, the PSRAB or the BCAS will continuously monitor reliability data and periodically review its original findings. In addition the Basic Certification Authority's document containing the CMP standard will be revised as necessary.

Appendix 2 — The Fail-Safe Design Concept

1 The Basic Certification Authority Design Concept

The FAR Part 25 airworthiness standards are based on, and incorporate, the objectives and principles or techniques, of the fail-safe design concept, which considers the effect of failures and combinations of failures in defining a safe design. The following basic objectives pertaining to failure apply:

- (1) In any system or sub-system, the failure of any single element, component, or connection during any one flight (brake release through ground deceleration to stop) should be assumed regardless of its probability. Such single failures should not prevent continued safe flight and landing, or significantly reduce the capability of the aeroplane or the ability of the flight crew to cope with the resulting failure conditions.
- (2) Subsequent failures during the same flight, whether detected or latent, and combinations thereof, should also be assumed unless their joint probability with the first failure is shown to be extremely improbable.

2 Fail-Safe Principles and/or Techniques

The use of only one fail-safe principle or technique is seldom adequate. A combination of two or more is usually needed to provide a fail-safe design; i.e. to ensure that major failure conditions are improbable and that catastrophic failure conditions are extremely improbable. In order to ensure a safe design, the fail-safe design concept uses design principles or techniques as follows:

- (a) **Designed integrity and quality** including Life Limits, to ensure intended function and prevent failures. i.e. to ensure that major failure conditions are improbable and that catastrophic failure conditions are extremely improbable.
- (b) **Redundancy or backup systems** to enable continued function after any single (or other number of) failure(s); e.g. two or more hydraulic systems, flight control systems, etc.
- (c) **Isolation of systems, components, and elements** so that the failure of one does not cause the failure of another. Isolation is also termed independence.
- (d) **Proven reliability** so that multiple, independent failures are unlikely to occur during the same flight.
- (e) **Failure warning or indication** to provide detection.
- (f) **Flight crew procedures** for use after failure detection, to enable continued safe flight and landing by specifying crew correction action.
- (g) **Check procedures** – the capability to check a component's condition.
- (h) **Designed failure effect limits** including the capability to sustain damage, to limit the safety impact or effects of a failure.

- (i) **Designed failure path** to control and direct the effects of a failure in a way that limits its safety impact.
- (j) **Margins or factors of safety** to allow for any undefined or unforeseeable adverse conditions.
- (k) **Error-tolerance** that considers adverse effects of foreseeable errors during the aeroplane's design, test, manufacture, operation, and maintenance.

APPENDIX 3 — Suitable En Route Alternate Aerodromes

1 General

One of the distinguishing features of two-engine extended-range operations is the concept of a suitable en route alternate aerodrome being available to which an aeroplane can divert after a single failure or failure combinations that require a diversion. Whereas most two-engine aeroplanes operate in an environment where there is usually a choice of diversion aerodromes available, the extended-range aeroplane may have only one alternate within a range dictated by the endurance of a particular airframe system (e.g. cargo fire suppressant), or by the approved maximum diversion time for that route.

It is, therefore, important that any aerodrome designated as an en route alternate has the capabilities, services, and facilities to safely support that particular aeroplane, and that the weather conditions at the time of arrival provide a high assurance that adequate visual references are available upon arrival at decision height (DH) or minimum descent altitude (MDA), and that the surface wind conditions and corresponding runway surface condition are within acceptable limits to permit the approach and landing to be safely completed with an engine and/or systems inoperative.

2 Adequate Aerodrome

As with all other operations, an operator desiring any route approval should show that it is able to satisfactorily conduct scheduled operations between each required aerodrome other than that route or route segment. Operators should show that the facilities and services specified are adequate for the proposed operation by the aeroplane type concerned.

3 Suitable Aerodrome

For an aerodrome to be suitable for the purpose of this Civil Aviation Advisory Circular, it should have the capabilities, services and facilities necessary to designate it as an adequate aerodrome and have weather and field conditions at the time of the particular operation which provide a high assurance that an approach and landing can be safely completed with an engine and/or systems inoperative in the event that a diversion to the en route alternate becomes necessary. Due to the natural variability of weather conditions with time as well as the need to determine the suitability of a particular en route aerodrome prior to departure, the en route alternate minima for dispatch purposes are generally higher than the 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 the alternate aerodrome. Additionally, since the visual reference necessary to safely complete an approach and landing is determined, among other things, by the accuracy with which the aeroplane can be controlled along the approach path by reference to instruments and the accuracy of the ground-based instrument aids, as well as the tasks the pilot is required to accomplish to manoeuvre the aeroplane so as to complete the landing, the weather minima for non-precision approaches are generally higher than for precision approaches.

4 En Route Alternate Aerodrome Weather Minima

4.1 Standard En route Alternate Aerodrome Weather Minima

The following are established for flight planning and dispatch purposes with two-engine aeroplanes in extended-range operations. These weather minima recognise the benefits of precision approaches, as well as the increased assurance of safely completing an instrument approach at aerodromes which are equipped with precision approaches to at least two separate runways, (two separate landing surfaces). A particular aerodrome may be considered to be a suitable aerodrome for flight planning and dispatch purposes for extended-range operations if it meets the criteria of Paragraph 3 of this Appendix and has

one of the following combinations of instrument approach capabilities and en route alternate aerodrome weather minima:

- (a) **A Single Precision Approach:** Cloud-base of 600 feet and a visibility of 3000 metres or a cloud-base of 400 feet and a visibility of 1500 metres above the lowest authorised landing minima; whichever is higher.
- (b) **Two or More Separate Precision Approach Equipped Runways:** Cloud-base of 400 feet and a visibility of 1500 metres or a cloud-base of 200 feet and a visibility of 800 metres above the lowest authorised landing minima; whichever is higher.
- (c) **Non-precision approach(es):** Cloud-base of 800 feet and a visibility of 4000 metres or a cloud-base of 400 feet and a visibility of 1500 metres above the lowest authorised landing minima; whichever is higher.

4.2 Lower Than Standard En route Alternate Aerodrome Weather Minima

Lower than standard en route alternate aerodrome weather minima may be considered for approval for certain operators on a case-by-case basis by the Director, at suitably equipped aerodromes for certain aeroplanes which have the certificated capability to safely conduct Category II and/or Category III approach and landing operations after encountering any failure condition in the airframe and/or propulsion systems which would result in a diversion to an en route alternate aerodrome. Subsequent failures during the diversion, which would result in the loss of the capability to safely conduct and complete Category II and/or Category III approach and landing operations, should be shown to be improbable. The certificated capability of the aeroplane should be evaluated considering the approved maximum diversion time. Lower than standard en route alternate weather minima may be considered at suitably equipped aerodromes, if appropriate, for those aeroplanes which have these approved capabilities considering the established maximum diversion time.

5 En route Alternate Suitability In-Flight

The suitability of an en route alternate aerodrome for an aeroplane which encounters a situation in-flight which necessitates a diversion, while en route on an extended-range operation is based on a determination that the aerodrome is still suitable for the circumstances and the weather and field conditions at that aerodrome will permit an instrument approach to be initiated and a landing completed.

APPENDIX 4 — ETOPS Maintenance Requirements

1 General

The maintenance programme for aeroplanes used in 75, 120 and 180 minute ETOPS should contain the standards, guidance and direction necessary to support the intended operations. Maintenance personnel developing and using this programme should be made aware of the special nature of ETOPS and have the knowledge, skills and ability to accomplish the requirements of the programme.

2 ETOPS maintenance programme

2.1 Aeroplane suitability

The airframe-engine combination being submitted for ETOPS consideration will be reviewed by the Basic Certification Authority (and if a US manufactured airframe-engine combination by the Propulsion System Reliability Assessment Board [PSRAB]). The CAA will review data accrued by the world fleet and the operator from operation of ETOPS candidate aeroplanes to help establish the operator's capability to conduct ETOPS operations. This candidate aeroplane should meet the requirements of this Advisory Circular. The CAA will review data on the airframe-engine combination and identify any conditions that exist which could prevent safe operation.

Note: *The candidate aeroplane for a 75-minute diversion time is not required to have achieved a predetermined number of hours or in-flight shutdown rate for this assessment.*

2.2 Maintenance programme

The basic maintenance programme for the aeroplane being considered for ETOPS is the continuous airworthiness maintenance programme currently approved for that operator, for the make and model airframe-engine combination. This programme will be reviewed by the CAA to ensure that it provides an adequate basis for development of a supplemental ETOPS maintenance programme. ETOPS maintenance requirements will be expressed in, and approved by the CAA as, supplemental requirements. This shall include maintenance procedures to preclude identical action being applied to multiple similar elements in any ETOPS Significant system (e.g. fuel control change on both engines) unless an alternate means of compliance has been agreed with the CAA. This relates to common cause concerns identified in Appendix 1.

- (a) ETOPS related tasks should be identified on the operator's routine work forms and related instructions.
- (b) ETOPS related procedures, such as involvement of centralised maintenance control, should be clearly defined in the operator's programme.
- (c) An ETOPS service check should be developed to verify that the status of the aeroplane and certain critical items are acceptable. This check should be accomplished and signed off by an ETOPS qualified maintenance person immediately prior to an ETOPS flight.

Note: *The service check may not be required for the return leg of a 75-minute ETOPS flight in a benign area of operation (defined in Appendix 5).*

- (d) Logbooks and maintenance logs should be reviewed and documented as appropriate to ensure proper MEL procedures, deferred items, maintenance checks and that system verification procedures have been properly performed.

No change will be made to these procedures without the prior approval of the CAA

2.3 Scheduled Maintenance of Multiple Identical Systems.

Maintenance (including modifications) which will disturb multiple identical elements of propulsion systems, or other ETOPS significant systems, should not be scheduled during the same maintenance check. However operators may identify specific maintenance activities which are to be carried out to multiple systems on a planned basis (e.g. Boroscope inspections). Such activities may be performed without requiring a subsequent verification flight provided the operator has identified the activity and has a procedure in place which provides an equivalent level of safety. These procedures shall be included in the CAA approved Operators ETOPS Manual

Where disturbance to multiple systems is otherwise unavoidable during a scheduled check, the engineer performing the task may not repeat it on an identical system, on the same aeroplane, during the check. On these occasions separate engineers must carry out the respective systems tasks.

- i.e. Engineer "A" carries out the task on L.H. Engine (or significant system).
 Engineer "B" carries out the identical task on the R.H. Engine (or significant system).
 Engineer "C" required to carry out a Physical Check and certify both LH and RH tasks.

Special Note. 1. Physical check requirements: To show an equivalent level of safety the CAA require a physical check to be made to confirm that the work has been carried out satisfactorily. Therefore the third engineer is required.

Special Note. 2. Because of the special skills required for Boroscope inspections, the same engineer may carryout the inspection on both engines provided the operator can show an equivalent level of safety for Open/Close access tasks, such as two separate engineers to remove and refit the inspection covers, plus duplicate inspections.

Tasks which disturb multiple identical elements of ETOPS significant systems should be identified as such on operator's work forms and instructions. Upon completion of maintenance, complete and adequate testing shall be carried out in accordance with the Maintenance Manuals and modification instructions. A verification flight must be carried out where ground testing cannot provide positive assurance of serviceability.

2.4 Unscheduled Maintenance

Identical unscheduled maintenance may be carried out on propulsion systems or other ETOPS significant systems (e.g. fuel control change on both engines). Where available two engineers should be used as in the procedure for scheduled maintenance documented above. Where this is not possible then one engineer may carry out the required task. This shall require complete testing in accordance with the Aeroplane Maintenance Manual procedures to provide positive assurance of serviceability. A verification flight must be carried out where ground testing cannot provide positive assurance of serviceability.

2.5 System Disturbance

Replenishment of aeroplane systems is not considered to disturb multiple similar elements of ETOPS significant systems, e.g. IDG, Engine Oil, Hydraulic System Servicing, etc. However disturbance of the component parts of these fluid systems or engine fuel system requires a high power engine ground run to check system integrity.

2.6 ETOPS manual

The operator shall develop a manual for use by personnel involved in ETOPS. This manual need not be all inclusive but should at least reference the maintenance programmes and other requirements described by this AC and clearly indicate where they are located in the

operator's manual system. All ETOPS requirements, including supportive programmes, procedures, duties and responsibilities, should be identified and subject to revision control. This manual should be submitted to the Director 90 days before implementation of ETOPS flights. No change will be made to these procedures without the prior approval of the CAA.

2.7 Oil consumption programme

The operator's oil consumption programme should reflect the manufacturer's recommendations and be sensitive to oil consumption trends. It should consider the amount of oil added at the departing ETOPS stations with reference to the running average consumption; i.e. the monitoring must be continuous up to, and including, oil added at the ETOPS departure station. If the APU is required for ETOPS operation, it should be added to the oil consumption programme.

2.8 Engine condition monitoring

This programme should describe the parameters to be monitored, method of data collection and corrective action process. If oil analysis is meaningful to this make and model, it should be included in the programme. The programme should reflect manufacturer's instructions and industry practice. This monitoring will be used to detect deterioration at an early stage to allow for corrective action before safe operation is effected. The programme should ensure that engine limit margins are maintained so that a prolonged single-engine diversion may be conducted without exceeding approved engine limits (i.e. rotor speeds, exhaust gas temperatures) at all approved power levels and expected environmental conditions. Engine margins preserved through this programme should account for the effects of additional engine loading demands (e.g. anti-ice, electrical, etc.) which may be required during the single-engine flight phase associated with the diversion. (see Paragraph 5.2.(b).(5)).

2.9 Resolution of aeroplane discrepancies

The operator shall develop a verification programme and procedures shall be established to ensure corrective action and cause determination following an engine shutdown, ETOPS significant system failure, adverse trends or any prescribed events which require a verification flight or other action and establish means to assure their accomplishment. ETOPS significant systems, and conditions requiring verification actions should be described in the operator's ETOPS maintenance manual. A clear description of who must initiate verification actions and the section or group responsible for the determination of what action is necessary should be identified in the programme.

Where an operator has not yet developed an acceptable "ETOPS significant systems" list the following conditions shall apply—

Where an aeroplane is included in the operators ETOPS programme, defects that occur in flight which would not permit dispatch of the aeroplane on an ETOPS flight under the conditions of the Minimum Equipment list (MEL) at the operators most extensive diversion time limit, shall be notified to the Director whether or not an ETOPS flight is being flown.

2.10 ETOPS significant systems

In developing the procedures for significant systems the following table should be considered as a starting point. For further guidance, the Configuration, Maintenance and Procedures (for ETOPS) document (CMP) should also be consulted.

ETOPS significant systems by ATA Chapter.

ATA Chapter	ETOPS Significant Systems	ATA Section
21 Air Conditioning	Cabin Pressure Control System	-31
	AC Packs	-51
	Air Temperature Control	-51
	E/E Cooling	-58
24 Electrical Power	Electrical Power	-00
	AC Generation	-20
	Power and Regulation	-21
	Fault Sensing	-23
	HMG System	-25
	DC Meters	-34
26 Fire Protection	Detection	-10
	Engine Fire Detection	-11
	APU Fire Detection	-15
	Lower Cargo Smoke Detection	-16
	Cargo Compartment Fire Extinguishing	-23
28 Fuel	Engine Fuel Feed System	-22
	APU Fuel Feed System	-25
30 Ice / Rain Protection	Wing Thermal Anti-Icing	-11
	Engine Inlet Thermal Anti-Icing	-21
	Pitot Static Probe Anti-Icing	-31
	Total Air Temperature Probe Heat	-33
	Engine Probe Heat	-34
	Flight Compartment Window Anti-Icing	-41
34 Navigation	Weather Radar System	-43
36 Pneumatic	Air Supply Distribution System	-11
49 Airborne Auxiliary Power	Auxiliary Power Unit	-11
	APU Mounts	-13
	APU Harness	-14
	APU Air Intake	-15
	APU Drains and Vents	-16
	APU Engine	-21
	APU and Generator Lubrication Systems	-27
	APU Fuel System	-31
	APU Ignition/Starting System	-41
	APU Cooling Air System	-51
	APU Surge Bleed System	-53
	APU Control System	-61
	APU Exhaust Gas Temperature Indicating System	-71
	APU Exhaust System	-81
All Engine Chapter-Section Items are ETOPS Significant EXCEPT those listed below		
	Thrust Reverser System	78-31
	Thrust Reverser Control System	78-34

2.11 ETOPS Verification Flight

This is a flight to establish that the aeroplane is satisfactory for ETOPS operation.

Prior to despatch on an ETOPS flight following an ETOPS significant system failure, reason or cause must be positively identified and rectified.

It is permissible to designate the period of time from airport departure to the ETOPS entry point as a maintenance verification flight, in combination with a regularly scheduled ETOPS revenue flight, provided the verification phase is documented as satisfactorily completed upon reaching the ETOPS entry point.

When this type of ETOPS verification flight is conducted, written procedures must be in place to ensure that the flight crew is fully briefed prior to dispatch concerning the event and/or the maintenance performed that necessitated the verification flight. Maintenance personnel should convey to the flight crew the specific observations and/or actions required of them during the verification portion of the flight as well as the method to be used to properly record the satisfactory completion of that verification flight.

Following an ETOPS significant system component change, (this includes an engine or APU), the aeroplane system is considered ETOPS serviceable upon satisfactory completion of the Maintenance Manual test procedures.

Where multiple similar systems are disturbed and the failure of the system would cause an in flight shut down or aeroplane turn back then a non-revenue verification flight or non ETOPS flight must be carried out. In addition the Certifying Engineer may request an ETOPS Verification Flight as appropriate. A non revenue verification flight or non ETOPS flight must be carried out where ground testing cannot provide positive assurance of serviceability.

In the event of a dual engine change a non revenue ETOPS Verification Flight must be carried out prior to the next revenue flight.

2.12 Intermittent Defects

Reasonable maintenance action must be taken to isolate faults that are intermittent in nature. If the fault can not be positively corrected then an ETOPS Verification Flight to assure defect rectification must be carried out.

If the defect does reoccur within the first 60 minutes then the flight shall return to the departure airport or other suitable airport.

2.13 Reliability programme

An ETOPS reliability programme should be developed or the existing reliability programme supplemented. This programme should be designed with early identification and prevention of ETOPS related problems as the primary goal. The programme should be event-orientated and incorporate reporting procedures for significant events detrimental to ETOPS flights. This information should be readily available for use by the operator and the CAA to help establish that the reliability level is adequate and to assess the operator's competence and capability to safely continue ETOPS.

The Director should be notified within 72 hours of events reportable through this programme, including:

- (a) Those defects required to be reported by Rule Part 12, and AC12-1 as soon as practicable (within 72 hours) and then followed up by a detailed report within 10 days of the incident in accordance with Rule Parts 12.55 and 12.57
- (b) Before the end of the 10th day of the following month, the operator shall provide a summary report of the following occurrences for the proceeding month:

- (1) Aeroplane operations/utilisation.
- (2) Engine operations/utilisation.
- (3) Each interruption to a flight, unscheduled change of aeroplane en route, or unscheduled stop or diversion from a route, caused by known or suspected mechanical difficulties.
- (4) Reportable defects and events reported to the Director as required by this appendix
- (5) System Defect Summary reports (PIREPS), which have exceeded their Alert level (by ATA Chapter)
- (6) MEL usage (by ATA Chapter).
- (7) Component unscheduled removals (by ATA Chapter).

2.14 Propulsion system monitoring

Firm criteria should be established as to what action is to be taken when adverse trends in propulsion system conditions are detected. When the propulsion system IFSD (computed on a 12-month rolling average) exceeds .05/1000 engine hours for a 120-minute operation, or exceeds .03/1000 engine hours for a 180-minute operation, an immediate evaluation should be accomplished by the operator and the CAA. A report of problems identified and corrective actions taken will be forwarded to the Director. Additional corrective action or operational restriction may be recommended.

2.15 Maintenance training

The maintenance training programme should focus on the special nature of ETOPS. This programme should be included in the normal maintenance training programme. The goal of this programme is to ensure that all personnel involved in ETOPS are provided the necessary training so that the ETOPS programmes are properly accomplished to the Director's satisfaction, and to emphasise the special nature of ETOPS maintenance requirements. Qualified maintenance personnel are those that have completed the operator's approved extended-range training programme. Have satisfactorily performed extended-range tasks under the direct supervision of a certificated maintenance person, who has had previous experience with maintaining the particular make and model aeroplane being utilised under the operator's approved maintenance programme. Recurrent training should take place at 2 year intervals.

2.16 ETOPS parts control

The operator should develop a parts control programme that ensures the proper parts and configuration are maintained for ETOPS. The programme includes verification that parts placed on ETOPS aeroplanes during parts borrowing or pooling arrangements, as well as those parts used after repair or overhaul, maintain the necessary ETOPS configuration for that aeroplane.

APPENDIX 5 — ETOPS Operational Programme Criteria

1 General

Paragraphs 7.1 through 7.8 of this Advisory Circular detail the criteria for operational approval of extended-range operations with a maximum diversion time of 120 minutes to an en route alternate (at approved single-engine inoperative cruise speed). This appendix serves the function of differentiating the criteria for approval of operations less than 120 minutes (75 minutes) and beyond 120 minutes (180 minutes). For approval of 75-minute operations, not all of the requirements of this Advisory Circular need necessarily be met. For approval of 180 minute operations, all of the requirements of the basic Advisory Circular must be met along with the requirements identified in this Appendix as necessary for 180-minute operations.

2 75-Minute Operation

The criteria detailed below are the basis for evaluating different areas of operation and requirement for approving 75-minute operation.

2.1 Benign area of operation

To be defined as a benign area of operation, the following considerations should apply:

- (a) Numerous adequate aerodromes.
- (b) A high level of reliability and availability are required of communications, navigation and ATC services and facilities.
- (c) Prevailing weather conditions are stable and generally do not approach extremes in temperature, wind, ceiling and visibility.

2.2 Criteria for deviation to operate in a benign area of operation

- (a) **Type design** — The airframe-engine combination should be reviewed to determine if there are any factors which would effect safe conduct of operations. Type design ETOPS approval criteria are not necessarily required.
- (b) **Maintenance programmes** — These should follow the guidance in Appendix 4 for 75-minute programmes.
- (c) **Operational programmes:**
 - (1) **Minimum equipment list:** Provision of the MMEL, excluding “Extended-range” provisos, apply.
 - (2) **Dispatch limitations:** Flight should be operated at a weight that permits the flight, at approved one-engine inoperative cruise speed and power setting, to maintain flight altitude at or above the Minimum En route Altitude.
- (d) **Demanding area of operation** — A demanding area of operation for the purpose of 75-minute approval has one or more of the following characteristics:
 - (1) **Weather:** Prevailing weather conditions can approach extremes in winds, temperature, ceiling and visibility for protracted periods of time.
 - (2) **Alternates:** Adequate aerodromes are not numerous.
 - (3) **Due to remote area or over-water,** a high level of reliability and availability of communications, navigation and ATC facilities services may not exist.

(e) **Criteria for deviation to operate in a demanding area of operation —**

- (1) **Type design:** The airframe-engine combination should be reviewed to determine any factors which could effect safe operations in the demanding area of operations. Type design ETOPS approval criteria are not necessarily required.
- (2) **Maintenance programmes** should be instituted which follow the guidance in Appendix 4 for 120-minute operation.
- (3) **Operation programmes** should be instituted which follow the guidance contained in this Advisory Circular for 120-minute programmes.

3 180-Minute Operation

3.0 General

Each operator requesting approval to conduct extended-range operations beyond 120 minutes should have approximately 12 consecutive months of operational in-service experience with the specified ETOPS configured airframe-engine combination in the conduct of 120-minute operations. The substitution of in-service experience which is equivalent to the actual conduct of 120 minute operations will be established by the Director, on a case-by-case basis. Prior to approval, the operator's capability to conduct operations and implement effective ETOPS programmes in accordance with the criteria detailed in Paragraph 10 of this Civil Aviation Advisory Circular will be examined. Only operators who have demonstrated capability to conduct a 120-minute programme successfully will be considered for approval beyond 120 minutes. These operators should also demonstrate additional capabilities discussed in this paragraph. Approval will be given on a case-by-case basis for an increase to their area of operation beyond 120 minutes. The area of operation will be defined by a maximum diversion time of 180 minutes to an adequate aerodrome at approved one-engine inoperative cruise speed (under standard conditions in still air). The dispatch limitation will be a maximum diversion time of 180 minutes to a suitable aerodrome at approved single-engine inoperative speed (under standard conditions in still air).

3.1 Dispatch considerations

- (a) **MEL** — The MEL should reflect adequate levels of primary system redundancy to support 180-minute (still air) operations. The systems listed in Paragraph 7.4.2 (a) through (o) should be considered.
- (b) **Weather** — An operator should substantiate that the weather information system which it utilises can be relied upon to forecast terminal and en route weather with a reasonable degree of accuracy and reliability in the proposed area of operation. Such factors as staffing, dispatcher training, sources of weather reports and forecasts and when possible, a record of forecast reliability should be evaluated.
- (c) **Fuel** — The critical fuel scenario should also consider fuel required for all engine operations at 10,000 feet or above 10,000 feet if the aeroplane is equipped with sufficient supplemental oxygen in accordance with Part 91.
- (d) **Operational control practices and procedures** — During the course of the flight, the flight crew should be informed of any significant changes in conditions at designated en route alternates. Prior to a 180-minute ETOPS flight proceeding beyond the extended-range entry point, the forecast weather for the time periods established in paragraph 7.4.4 (d) (3), landing distances and aerodrome services and facilities at designated en route alternates should be evaluated. If any conditions are identified (such as weather forecast below landing minima) which would preclude safe approach and landing, the pilot should be notified and an acceptable alternate(s) selected where safe approach and landing can be made. The maximum diversion time to the newly selected alternate(s)

should not exceed 180 minutes at the approved single-engine inoperative cruise speeds (under standard conditions in still air).

- (e) **Flight planning** — Operators should provide for compliance with Civil Aviation Rules. The effects of wind and temperature at single-engine inoperative cruise altitude should be accounted for. In addition, the operator's programme should provide flight crews with information on suitable aerodromes appropriate to the route to be flown which are not forecast to meet Appendix 3 en route alternate weather minima. Aerodrome facility information, and other appropriate planning data concerning these aerodromes should be provided to flight crews for use in complying with Civil Aviation Rules when executing a diversion.

3.2 Crew training and evaluation

- (a) **Standby Power** — If standby sources of electrical power significantly degrade cockpit instrumentation to the pilots, then approved training which simulates approach with the standby generator as the sole power source should be conducted during initial and recurrent training.
- (b) **Contingency procedures** — Flight crews should be provided detailed initial and recurrent training which emphasises established contingency procedures for each area of operation intended to be used.
- (c) **Diversion decision making** — Special initial and recurrent training to prepare flight crews to evaluate probable propulsion and airframe systems failures should be conducted. The goal of this training should be to establish crew competency in dealing with the most probable operating contingencies

3.3 Equipment

- (a) **VHF/Satellite data link** — Operators should consider enhancements to their operational control system as soon as they become feasible.
- (b) **Automated system monitoring** — Automated aeroplane system status monitoring should be provided to enhance the flight crew's ability to make timely diversion decisions.

4 Validation Flight or Flights

The operator should demonstrate by means of a CAA witnessed validation flight that it has the capability to safely conduct 180-minute operations with the specified airframe-engine combination. The guidance for validation flights contained in Paragraph 7.8 of this Advisory Circular should be followed.

Appendix 6 – Simulated Extended-range (ETOPS) Programme

1 General

Paragraph 6.2.3 of this AC states that "the substitution of in-service experience which is equivalent to the actual conduct of 120-minute ETOPS operations will be established by the Director, on a case by case basis." The purpose of this appendix is to establish the conditions under which the Director, may exercise the authority to allow an operator to gain ETOPS in-service experience through a simulation/demonstration programme as a prerequisite for applying for 180-minute ETOPS authority.

The purpose of these guidelines is to establish the criteria for an acceptable simulation and demonstration programme. The intent of such a programme will be to permit an airline which does not have the capability to demonstrate ETOPS operations due to route structure to develop and validate an ETOPS programme leading to 180-minute approval. It is the objective of the ETOPS simulation and demonstration programme to provide the applicant with an acceptable level of experience to demonstrate its capability to safely operate an extended-range operation with a maximum diversion of up to 180 minutes. Future developments in aeroplane/engine design, testing and operational programmes may lead to a review of operator in-service experience requirements; however, presently such requirements are considered one of the basic tenets on which operational approval is based.

2 Applicant in-service Experience Requirements

Operators who desire to obtain 180-minute ETOPS authority through the simulation/demonstration programme should have obtained approximately 12-consecutive months of operational in-service experience with the specified airframe-engine combination before start up of simulated ETOPS flight.

3 Authority Granted Through Simulation/Demonstration Programme

Operations specification authority granted for 180-minute ETOPS through the simulation/demonstration programme should be initially limited to the areas of operation in which the applicant has demonstrated capability. Initial approval to conduct 180-minute ETOPS will be granted by the Director, in accordance with paragraph 7.8.1 of this Advisory Circular. Approval of the operator for additional 180-minute ETOPS areas of operation will also be made by the Director. Factors such as the operator's 180-minute ETOPS and overall in-service experience record, the characteristics of the area of operation requested (demanding or benign), and the in-service record of the aeroplane-engine combination should be considered on a case-by-case basis

4 Flight Safety

The operator should show that it has considered the impact of the ETOPS simulation/demonstration programme on actual operations. The operator should state in its application its policy guidance to personnel involved in the ETOPS simulation/demonstration programme in regards to flight safety. This guidance should clearly state that simulated ETOPS programmes exercises should not be allowed to impact the safety of actual operations especially during periods of abnormal or emergency operations or high cockpit workload, operations. It should emphasize that during periods of abnormal or emergency operation or high cockpit workload ETOPS simulation should be terminated.

5 Simulation/Demonstration Programme Requirements

The following is a list of basic elements for a simulation/demonstration programme. These elements should be addressed both in the operator's application and during operations conducted under the programme. Specific guidance on these items as they relate to the

simulation/demonstration programme can be found in this Appendix paragraph 8, Concepts for Simulation:

- (a) A fully developed and approved maintenance programme which includes a tracking and control programme.
- (b) An approved airframe, system and engine reliability monitoring and reporting systems.
- (c) An approved flight planning and dispatch programme.
- (d) An approved initial and recurrent training and checking programme for specific flight operations personnel.
- (e) An approved initial training and qualifications programme for ETOPS maintenance personnel.
- (f) A simulation scenario of sufficient frequency and operational exposure to demonstrate the application and response of maintenance and operational support systems.
- (g) A means to monitor and report ongoing ETOPS performance results during the period of the simulation to provide validation or, as necessary, recommended changes to ETOPS maintenance and operational support systems.
- (h) A resource allocation and decision making process which will demonstrate commitment by management and all personnel involved in ETOPS maintenance and operational systems support.

6 Pre-application

The process should begin with a letter from the operator to the Director of Civil Aviation identifying its intent to make application to conduct 180-minute extended-range operations. The letter should specify the aeroplane/engine combination intended to be used, the actual area of operations proposed, the proposed start of simulated ETOPS operation, proposed schedule of demonstration flights, and the proposed start of actual 180-minute ETOPS operation. If the proposed airframe-engine combination has not received type design approval for 180-minute ETOPS as of the date of the letter of application a status report on the aeroplane is required. It should be established that there is reasonable expectation of airframe-engine combination 180-minute type design approval before proposed start up of actual 180-minute operations.

7 Application to Conduct Simulated and Demonstration Flights

Approximately 90 days prior to the proposed start of simulated ETOPS flights, the operator should forward to the CAA a full ETOPS application which addresses the criteria contained in this AC and appendices for 180-minute ETOPS programmes. The application should also contain information on the proposed simulated operation, the proposed demonstration flights and the proposed actual operation. There may be certain items related to 180-minute and actual operations which the operator is not prepared to address at this time. These items should be addressed during the final application for 180-minute authority and the application for simulation/demonstration should be forwarded to the CAA for approval prior to the commencement of simulated ETOPS. The application should include:

- (a) Simulation and demonstration periods, start dates, and proposed completion dates.
- (b) List of aeroplane to be used in the simulation and demonstration. List should include registration numbers, manufacturer and serial number and model of the airframes and engines.

- (c) Description of the areas of operation proposed for simulated, demonstrated and actual operations.
- (d) List of designated ETOPS simulation and demonstration routes. Simulation routes should be of sufficient duration to provide adequate simulation. In most cases, these will be the operator's longest routes. Demonstration routes should be the proposed routes.
- (e) Description of the operator's relevant extended-range in-service experience with other airframe-engine combinations and/or relevant non-ETOPS in-service experience with the airframe engine combination to be used in the simulation. This description should include records of in-flight shutdowns; unscheduled engine removals, and significant operations events.
- (f) Description of aeroplane configuration with respect to the applicable CMP document at the start of simulation. and should include a schedule of compliance for items not yet incorporated or a statement of the date that full compliance is expected.

Note: *Items requiring incorporation are discussed in paragraph 8.3 of this Appendix.*

- (g) Minimum number of ETOPS simulation and demonstration missions performed.
- (h) Supplemental ETOPS maintenance programme which meets the requirements of Appendix 4 of this Advisory Circular.
- (i) A plan to ensure that maintenance personnel are qualified in accordance with Appendix 4 and applicable Civil Aviation Rules at proposed departure and destination airports in the actual area of operation This plan should be coordinated with the CAA
- (j) Policy guidance to personnel involved in the programme in regards to flight safety as stated in paragraph 4.
- (k) Operations programmes which meet the criteria of this Advisory Circular and the appendices.
- (l) A Gate and Milestone tracking plan to allow for the orderly tracking and documentation of specific requirements of the ETOPS.
- (m) Any other items relevant to the applicant's ETOPS programme requested by the Director.

8 Concepts for Simulation

The simulation should provide for accumulation of in-service experience which is equivalent to the actual conduct of ETOPS.

8.1 Area of Operations and Dispatch Limitation

The operator should identify a simulated area of operations and the alternates that it propose to use to meet the dispatch limitations for a suitable alternate.

8.2 Sample Size

The operator should plan on conducting simulated ETOPS with the specified airframe-engine for at least 12-consecutive months (see paragraph 9.4.(a) reference – configuration delays). The sample size should consist of approximately 1000 separate operations. These operations should be conducted on flights which contain approximately 3 hours of cruise flight. The number of operations and months of in-service experience may be increased or decreased following a review by the CAA on a case-by-case basis considering:

- (a) Operator experience with similar technology airframe-engine combinations in conducting ETOPS; i.e., 757/767 or A300/A310.
- (b) Operator experience with the specified airframe-engine combination.
- (c) Operator experience with non-ETOPS aeroplane in international over water operations.
- (d) The record of the aeroplane-engine combination in ETOPS with other operations.
- (e) Other scenarios.

8.3 Airframe-Engine Combination Build Standards:

- (a) **Engine/APU Items** — This statement applies equally to Engine manufacturer items, Engine Build Up Systems and Auxiliary Power Units on aeroplane proposed to be used to conduct simulated ETOPS flights. Normally, the configuration, maintenance, and operating items identified in the current approved Configuration, Maintenance, and Procedures (CMP) document should be implemented prior to the start of simulated ETOPS flights. However, items identified in the CMP document by an asterisk may be accomplished per the manufacturer's recommended schedule.
- (b) **Airframe Items** — It is recommended that aeroplane proposed to be used in the simulated ETOPS programme be configured to the CMP Build Standard for airframe items at the start of simulated ETOPS flights. Further, if certain equipment significantly impacts maintenance and/or operational procedures then the Director may require that it may be installed early in the simulation period. Airframe items which the applicant intends to incorporate at a later date should be identified in the application along with a schedule for compliance. During the final three months of the simulation period, all aeroplane used to conduct simulated ETOPS flights should fully comply with the CMP document.
- (c) **Equipment required by Civil Aviation Rules for Extended Over water Flight** — The applicant should identify any equipment required by Civil Aviation Rules for extended over water flight which is not installed at the start of simulated ETOPS operations. The applicant should present the CAA with a schedule for the installation of such equipment. If certain equipment significantly impacts maintenance and/or operational procedures then the Director
 - (d) may require that equipment be installed early in the simulation period.

8.4 Maintenance Programmes

The simulation programme should be designed to aid operators in the development of decision-making processes through implementation of supplemental ETOPS maintenance programmes as specified in Appendix 4 of this Advisory Circular. It is not within the scope of the Appendix to restate each required programme element, but to outline the extent of their application in simulated programmes.

8.4.1 Dispatch Considerations

All dispatch actions real or simulated including documentation of discrepancies should be completed prior to actual dispatch of the aeroplane. Operators conducting ETOPS simulations have the same dispatch options as would be exercised in actual extended-range operations.

- (a) **Minimum Equipment List (MEL)** — In instances in which the aeroplane does not meet the operator's ETOPS MEL requirements (but does meet non-ETOPS requirements), dispatch options should include:
 - (1) Taking appropriate action to clear MEL and operate as an ETOPS mission.

- (2) Substitute an ETOPS aeroplane and operate as an ETOPS mission.
 - (3) Operate the flight as a non-ETOPS mission.
- (b) Domestic Verification Flights — Instances in which the operator's programme prescribes a domestic verification flight prior to ETOPS, dispatch options could include:
- (1) Substitute an ETOPS aeroplane and operate as an ETOPS mission.
 - (2) Operate the flight as a non-ETOPS mission.
 - (3) Perform the verification flight in accordance with the approved CAA procedure and operate as an ETOPS mission.

8.4.2 ETOPS Destination Reliability Requirements

The excessive use of the option to operate as a non-ETOPS mission is not desirable in that it indicates a lack of commitment to the ETOPS programme. Therefore, during the period of simulation, ETOPS destination reliability should remain at 98% or higher. The ground rules for destination reliability requirements are as follows:

- (a) An ETOPS flight is considered reliable if it arrives at its planned destination within 6 hours of its planned arrival time.
- (b) If an ETOPS flight does not arrive at its intended destination within 6 hours of its planned arrival time due to factors unrelated to the operators maintenance or operations programmes, then the flight may be counted as reliable. Passenger medical emergencies, air traffic flow control and flights rescheduled for passenger load considerations are examples of flights that would not be counted against the operator.
- (c) Flights which are conducted under the non-ETOPS MEL are not considered as reliable for the destination reliability calculation.
- (d) Any ETOPS designated flight which is unreliable under the criteria specified above should be reported to the CAA within 72 hours of the event. The report should include:
 - (1) If maintenance-related, a description of the discrepancy or malfunction that caused the flight to be unreliable including operating under a non-ETOPS MEL.
 - (2) If operations-related, a description of the operational problem which caused the flight to be unreliable.
 - (3) Chronology of the problem beginning with the first notification to maintenance or operations personnel up to the time of flight termination or cancellation.
 - (4) The actions which followed initial notification of the problem.
 - (5) Logistical aspects surrounding the availability of repair parts and/or required maintenance equipment at the station where the problem occurred.
 - (6) Any other information that may be deemed pertinent to the factors which caused the flight to be unreliable.
- (e) The operator should compile destination reliability data and report to the Director each month starting from commencement of ETOPS simulation. This report should include:
 - (1) Number of flights scheduled during the period and total number scheduled since start of ETOPS simulation.

- (2) Number of flights considered reliable and unreliable during the period and since start of ETOPS simulation.
- (3) Percentage of flights considered reliable during the period and since the start of ETOPS simulation.
- (4) In-service experience data to include in-flight shutdown (IFSD) rates, (3-month, 6-month, 12-month rolling average, as agreed to by the Director), unscheduled engine removals and rates, delays and cancellations, airframe-engine hours and cycles, record of APU start and run reliability, and any other significant operator events required to be reported under the maintenance reliability programme identified in Appendix 4. Data such as IFSD rates and events for portions of the applicant's aeroplane-engine combination fleet which are not intended to be utilized in the ETOPS simulation also be reported.

8.5 Operations Programmes:

8.5.1 Training

Flight crew and dispatchers who participate in the simulation should have received ETOPS and international training prior to participation in the simulation.

8.5.2 Operations

Flights should be planned, dispatched and flown in accordance with this Advisory Circular. All dispatch actions real or simulated including documentation of discrepancies should be completed prior to actual dispatch of the aeroplane. (See paragraph 8.4.2). Flight crew and flight operations dispatchers should evaluate:

- (a) Critical fuel reserves — Flight crews and dispatchers should evaluate critical fuel requirements during ETOPS-simulated flights.
- (b) En route alternate suitability.
- (c) Computer flight plans including diversion data such as Equal Time Points, critical fuel requirements, heading information.
- (d) Minimum Equipment List (MEL) items.
- (e) Plotting charts — These should be annotated during flight planning as they would for an actual flight. En route plots should be made as prescribed in the FAA AC 90-79 Recommended Practices and Procedures for the use of Electronic Long-Range Navigation Equipment.
- (f) Communications — HF communication should be exercised to familiarize crews with its operational characteristics.
- (g) Technical assistance — Exercises should be conducted on selected flights to evaluate the availability and quality of assistance from maintenance technical centres.

8.6 CAA Involvement

A number of operations should be witnessed by CAA personnel. Simulated malfunctions and contingencies should be given to determine the operator's capability to respond correctly and expeditiously.

9 Concepts for Demonstration

9.0 Purpose of demonstration phase

The purpose of the demonstration phase shall be to gain experience and to validate effectiveness consistent with the highest level of safety over actual 180-minute routes.

Flights conducted during the demonstration phase should be conducted utilizing applicable Civil Aviation Rules and this Advisory Circular criteria for airframe-engine configuration, maintenance, dispatch and flight crew programmes.

9.1 Area of Operation

The demonstration flights should be conducted over intended routes. Exact tracks, points of entry, diversion airports and support facilities at origins and destinations should be established as if 180-minute authority were actually being exercised in regularly scheduled service.

9.2 Sample Size and Timing

Twelve (one-way) demonstration flights should be flown in the planned actual area of operations. The number of demonstration flights may be increased or decreased by the Director on a case-by-case basis based on the factors identified in paragraph 8.2.(a) through 8.2.(e). The initial flight should be flown approximately 90 days prior to the date of final application. The purpose of these flights will be to demonstrate proof of concept in the exercise of all operational and maintenance factors. Results of these flights will be used to modify programme elements to assure that subsequent flights fully conform to desired profiles.

9.3 Maintenance Programmes

All aircraft flying in the demonstration flights shall comply to configuration requirements as established in the configuration, maintenance and procedures (CMP) Document and applicable Civil Aviation Rules. Similarly, all training, dispatch, maintenance, and maintainability/reliability standards criteria shall be in full conformance with this Advisory Circular.

9.4 Configuration Compliance

All aeroplane flying in the demonstration flights shall comply to configuration requirements as established in the CMP Document and applicable Title 14 Code of Federal Regulations (14 CFR) or acceptable equivalent document. Similarly, all training, dispatch, maintenance, and maintainability/reliability standards criteria shall be in full conformance with this AC.

- (a) **Configuration delays** — Should a delay occur in the configuration of the operator's aeroplane (for example, due to part availability) the operator should continue to conduct the simulation programme until it is prepared to conduct demonstration flights.

9.5 Flight Profiles

Demonstration flight segments should be integrated into the carrier's operational schedule and submitted in advance to the CAA. All flights will conform to the carrier's operations specifications and 180-minute ETOPS criteria.

9.6 Diversion Exercises

During the course of the demonstration flights, ETOPS diversion exercises should be conducted in accordance with the established ground rules, at a frequency and extent to be determined by the CAA. The demonstration diversions shall be consistent with the guidelines established by the CAA for 180-minute ETOPS validation flights. Diversion exercises should not impact the applicant's destination reliability record or required number of simulation/demonstration flights.

9.7 Validation Flight Credit

At the discretion of the CAA, the final flight or flights conducted during the demonstration phase may be planned and conducted as the CAA-required ETOPS validation flight(s). This flight or flights should be coordinated between the CAA and the operator well in advance.

This provision does not alter the requirement to conduct simulation/demonstration for 12-consecutive months and approximately 1,000 flights.

10 Concepts for paper airline evaluation

10.0 Validation of accuracy and repeatability

To validate the accuracy and repeatability of data sources, flight planning methodology and algorithms, and operational decision processes, a "paper airline" data assimilation and analysis will be conducted in parallel to both the simulation and demonstration phases.

10.1 Area of Operation

The "paper airline" shall be "flown" over the exact route(s) intended for the regularly scheduled ETOPS flights.

10.2 Sample Size and Timing

A minimum of one flight per business day, per intended segment, will be planned. "Business day" is described as the period in which normal duties permit data retrieval and analysis. Where the frequency is less than daily, the "paper" scenario will still maintain a minimum analysis volume of at least 5 flights per week.

10.3 Maintenance Programme

Although maintenance activity simulation cannot be accommodated in a quantitative analysis scenario of this type, it is recommended that maintenance alert and MEL notification mechanisms be regularly exercised and displayed in conjunction with flight planning releases.

10.4 Configuration Compliance

Not applicable, but it should be assumed that the "paper" aeroplane in the planning data base for the daily analyses is fully conformed to CMP and ETOPS MEL requirements.

10.5 Paper Flight Analysis

For each paper flight, planned versus actual weather and facility status should be analysed. Items to be analysed should include:

- (a) Actual versus forecast en route ETOPS alternate, destination, and terminal alternate weather (ceiling, visibility, crosswind component, icing, runway).
- (b) Actual versus forecast en route weather.
- (c) Actual versus forecast condition of navigation, communication and airport facilities for en route, alternate, and terminal phase of flight.
- (d) Analysis of planned versus actual en route wind and the resultant variation in planned fuel burn off to determine impact on the critical fuel scenario.

10.6 Presentation of Results

During the course of the domestic simulation phase, results from the ongoing daily "paper airline" analyses will be made available for CAA review and comment. Summary reports will be prepared and forwarded monthly to the Director, including revised programmes or strategies developed as a result of conclusions derived from the parallel analyses.

11 Application for 180-Minute Authority

An application for 180-minute ETOPS authority should be submitted to the Director in accordance with paragraph 7.1 – Requesting Approval – of this Advisory Circular at least 90 days prior to the proposed start of 180-minute ETOPS validation flight or flights. The content of the application should be coordinated with the CAA prior to submittal. Generally,

the application should contain any in-service experience data or information on 180-minute ETOPS maintenance and/or operation programmes not previously submitted for evaluation or changed since original submittal. In cases where substantial changes have occurred over the course of simulation, the Director may request a complete ETOPS application.

12 ETOPS Validation Flight

A CAA-witnessed ETOPS validation flight or flights will be conducted in accordance with paragraph 7.8 and 7.9 of this Advisory Circular. The flight(s) may be scheduled following CAA review and approval of the operator's 180-minute ETOPS application. (See Paragraph 9.7 Validation Flight Credit for guidance on conducting validation flight or flights during the demonstration phase).

Appendix 7 — Reduction of operator's in-service experience requirement prior to the granting of ETOPS operational approval

(Accelerated ETOPS operational approval)

1 General

- (a) Paragraph 6.2 of this Advisory Circular in essence states the following:
- (1) (in-service experience) guidelines may be reduced or increased following review and concurrence on a case-by-case basis by the Director.
 - (2) Any reduction will be based on evaluation of the operators ability and competence to achieve the necessary reliability for the particular airframe-engine combination in extended-range operations.
 - (3) For example, a reduction in in-service experience may be considered for an operator who can show extensive in-service experience with a related engine on another aeroplane which has achieved acceptable reliability.
 - (4) The substitution of in-service experience which is equivalent to the actual conduct of 120-minute ETOPS operations will also be established by the Director on a case by case basis.
- (b) The purpose of this Appendix is to establish the factors which the Director, may consider in exercising the authority to allow reduction or substitution of operators in-service experience requirement in granting ETOPS Operational Approval.
- (c) Paragraph 4 of this Advisory Circular states that – “ the concepts for evaluating extended-range operations with two-engine aeroplanes ensure that two-engine aeroplanes are consistent with the level of safety required for current extended-range operations with three and four-engine turbine-powered aircraft without unnecessarily restricting operation.”
- (d) The excellent propulsion related safety record of two-engine aeroplanes has not only been maintained, but potentially enhanced by the process related provisions associated with ETOPS Type Design and Operational Approvals. Further, currently available data shows that these process related benefits are achievable without extensive in-service experience. Therefore, reduction or elimination of in-service experience requirements may be possible when the operator shows to the CAA that adequate and validated ETOPS processes are in place.
- (e) The Accelerated ETOPS Operational Approval Programme with reduced in-service experience does not imply that any reduction of existing levels of safety should be tolerated but rather acknowledges that an operator may be able to satisfy the objectives of this Advisory Circular by a variety of means of demonstrating that operator's capability.
- (f) This Appendix describes the means by which an operator may initiate ETOPS operations when the operator establishes the processes necessary for successful and reliable ETOPS operations are in place. This may be achieved by thorough documentation of processes, demonstration on another aeroplane/validation (as described in paragraph 7 of this Appendix) or a combination of these processes.

2 Background

- (a) When FAA AC 120-42 was first released in 1985, ETOPS was a new concept requiring extensive in-service verification of capability to assure the concept was a logical approach. At that time, the FAA recognized that reduction in the in-service experience requirements or substitution of in-service experience, on another aeroplane, would be possible.
- (b) The ETOPS concept has been successfully applied for over a decade; ETOPS is now widely employed and is well established. The number of ETOPS operators has increased dramatically; and in the North Atlantic, U.S. airlines have more twin operations than the number of operations accomplished by three and four-engine aeroplanes.
- (c) The basic ETOPS AC stipulates that an operator must generally operate an airframe-engine combination for one year, before being eligible for 120-minute ETOPS; and another one year, at 120-minute ETOPS, before being granted 180-minute ETOPS approval. For example, an operator who currently has 180-minute ETOPS approval on one type of airframe-engine or who is currently operating that route with an older generation three- or four-engine aeroplane was required to wait for up to two years for such an approval. Such a requirement could create undue economic and operational burdens on operators. On the other hand, data indicates that compliance with the alternative processes of this Appendix will provide for successful ETOPS operation at earlier than the standard time established in the basic Advisory Circular.
- (d) ETOPS operational data indicates that twin-engine aeroplanes have maintained a high degree of reliability due to implementation of specific maintenance, engineering, and flight operation process-related requirements. Compliance with ETOPS processes is crucial in assuring high levels of reliability of twin engine aeroplanes. Data also indicates that previous experience with an airframe-engine combination prior to operating ETOPS, does not necessarily make a significant difference in the safety of such operations. Commitment to reliable ETOPS processes has been found to be a much more significant factor; such commitment, by operators, has, from the outset, resulted in operation of twin-engine aeroplanes at a mature level of reliability.
- (e) ETOPS experience of the past decade clearly demonstrates that a firm commitment by the operator to establish proven ETOPS processes prior to the start of actual ETOPS and dedication to that commitment throughout the life of the programme is paramount to safe and reliable ETOPS operations.

3 Definitions

3.1 Process

A process is a series of steps or activities that are accomplished, in a consistent manner, to assure that a desired result is attained on an ongoing basis. Paragraph 4 documents ETOPS processes that should be in place to ensure a successful Accelerated ETOPS programme.

3.2 Proven Process

A process is considered to be proven when the following elements are developed and implemented:

- (a) Definition and documentation of process elements.
- (b) Definition of process related roles and responsibilities.
- (c) Procedure for validation of process or process elements.
 - (1) Indications of process stability/reliability.

- (2) Parameters to validate process and monitor (measure) success.
- (3) Duration of necessary evaluation to validate process.
- (d) Procedure for follow-up in-service monitoring to assure process remains reliable/stable. Methods of process validation are provided in paragraph 7 of this Appendix

4 ETOPS Processes

- (a) The two-engine airframe/engine combination for which the operator is seeking Accelerated ETOPS Operational Approval must be ETOPS Type Design approved (and determined to be operating at a level of reliability as specified in Appendix 1) prior to commencing ETOPS. The operator seeking Accelerated ETOPS Operational Approval must demonstrate to the CAA that it has an ETOPS programme in place that addresses the process elements identified in this section.
- (b) The following are the ETOPS process elements:
 - (1) Aeroplane/engine compliance to Type Design Build Standard (CMP).
 - (2) Compliance with the Maintenance Requirements as defined in paragraph 7. of this Advisory Circular and Appendix 4 of this Advisory Circular:
 - (i) Fully developed Maintenance Programme. (Appendix 4, paragraph 2.2) which includes a tracking and control programme.)
 - (ii) ETOPS manual. (Appendix 4, paragraph 2.6 in place.)
 - (iii) A proven Oil Consumption Monitoring Programme. (Appendix 4, paragraph 2.7).
 - (iv) A proven Engine Condition Monitoring and Reporting system. (Appendix 4, paragraph. 2.8).
 - (v) A proven Plan for Resolution of Aeroplane Discrepancies. (Appendix 4, paragraph 2.9).
 - (vi) A proven ETOPS Reliability Programme. (Appendix 4, paragraph 2.13).
 - (vii) Propulsion system monitoring programme (Appendix 4, paragraph 2.14). in place. The operator should establish a programme that results in a high degree of confidence that the propulsion system reliability appropriate to the ETOPS diversion time would be maintained.
 - (viii) Training and qualifications programme in place for ETOPS maintenance personnel. (Appendix 4, 2.15).
 - (ix) Established ETOPS parts control programme Appendix 4, 2.16).
- (c) Compliance with the Flight Operations Programme as defined in paragraph 7 and Appendix 5 of this AC:
 - (1) Proven flight planning and dispatch programmes appropriate to ETOPS.
 - (2) Availability of meteorological information and MEL appropriate to ETOPS.
 - (3) Initial and recurrent training and checking programme in place for ETOPS
 - (4) Flight crew and dispatch personnel familiarity assured with the ETOPS routes to be flown; in particular the requirements for, and selection of, en route alternates.

- (d) Documentation of the following elements:
- (1) Technology new to the operator and significant difference in primary & secondary power (engines, electrical, hydraulic and pneumatic) systems between the aeroplanes currently operated and the two-engine aeroplane for which the operator is seeking Accelerated ETOPS Operational Approval.
 - (2) The plan to train the flight and maintenance personnel to the differences identified in subparagraph (1) above.
 - (3) The plan to use proven manufacturer-validated Training and Maintenance and Operations Manual procedures relevant to ETOPS for the two-engine aeroplane for which the operator is seeking Accelerated ETOPS Operational Approval.
 - (4) Changes to any previously proven validated Training, Maintenance or Operations Manual procedures described above. Depending on the nature and extent of any changes, the operator may be required to provide a plan for validating such changes.
 - (5) The validation plan for any additional operator unique training and procedures relevant to ETOPS.
 - (6) Details of any ETOPS programme support from the airframe manufacturer, engine manufacturer, other operators or any other outside person.
 - (7) The control procedures when maintenance or flight dispatch support is provided by an outside person as described above.

5 Application

- (a) Paragraph 7.1 of this AC requires that requests for extended-range operations be submitted at least ninety days prior to the start of extended-range operations. Normally, the operator should submit an Accelerated ETOPS Operational Approval Plan to the CAA six months before the proposed start of extended-range operations. This time will permit the CAA to review the documented plans and assure adequate ETOPS processes are in place. The operators application for Accelerated ETOPS should:
- (1) Define proposed routes and the ETOPS diversion time necessary to support these routes.
 - (2) Define processes and related resources being allocated to initiate and sustain ETOPS operations in a manner that demonstrates commitment by management and all personnel involved in ETOPS maintenance and operational support.
 - (3) Identify, where required, the plan for establishing compliance with the build standard required for Type Design Approval; e.g., CMP (Configuration, Maintenance and Procedures Document) compliance.
 - (4) Document plan for compliance with requirements in paragraph 4.
 - (5) Define Review Gates. A Review Gate is a milestone tracking plan to allow for the orderly tracking and documentation of specific requirements of this Appendix. Each Review Gate should be defined in terms of the tasks to be satisfactorily accomplished in order for it to be successfully passed. Items for which the CAA visibility is required or the CAA approval is sought should be included in the Review Gates. Normally, the Review Gate process will start six months before the proposed start of extended-range operations and should continue at least until six

months after the start of extended-range operations. Assure that the proven processes comply with the provisions of paragraph 3 of this Appendix.

6 Operational Approvals

- (a) Operational approvals that are granted with reduced in-service experience will be limited to those areas agreed on by the CAA at approval of the Accelerated ETOPS Operational Approval Plan. When an operator wishes to add new areas to the approved list, CAA approval is required.
- (b) Operators will be eligible for ETOPS Operational Approval up to the Type Design Approval limit, provided the operator complies with all the requirements in paragraph 4.

7 Process Validation

- (a) Paragraph 4 identifies those process elements that need to be proven prior to start of Accelerated ETOPS.
- (b) For a process to be considered proven, the process must first be defined. Typically, this will include a flow chart showing the various elements of the process. Roles and responsibilities of the personnel who will be managing this process should be defined including any training requirement. The operator should demonstrate that the process is in place and functions as intended. The operator may accomplish this by thorough documentation and analysis, or by demonstrating on an aeroplane that the process works and consistently provides the intended results. The operator should also show that a feedback loop exists to illustrate need for revision of the process, if required, based on in-service experience.
- (c) Normally the choice to use, or not use, demonstration on an aeroplane as a means of validating the process should be left up to the operator. With sufficient preparation and dedication of resources such validation may not be necessary to assure processes produce acceptable results. However, in any case where the proposed plan to prove the processes is determined by the CAA to be inadequate or the plan does not produce acceptable results, validation of the process in an aeroplane will be required.
- (d) If an operator is currently operating ETOPS with a different airframe and/or engine combination it may be able to document that it has proven ETOPS processes in place and only minimal further validation may be necessary. It will; however, be necessary to demonstrate that means are in place to assure equivalent results will occur on the aeroplane being proposed for Accelerated ETOPS Operational Approval. The following elements which while not required, may be useful or beneficial in justifying a reduction in the validation requirements of ETOPS processes:
 - (1) Experience with other airframes and/or engines.
 - (2) Previous ETOPS experience.
 - (3) Experience with long range, over water operations with two, three, or four engine aeroplanes.
 - (4) Experience gained by flight crews, maintenance personnel, and flight dispatch personnel while working with other ETOPS-approved operators.
- (e) Process validation may be done in the airframe-engine combination that will be used in Accelerated ETOPS operation or in a different type aeroplane than that for which approval is being sought, including those with three or four engines.

- (f) A process may be validated by first demonstrating the process produces acceptable results on a different aeroplane type or airframe-engine combination. It should then be necessary to demonstrate that means are in place to assure equivalent results should occur on the aeroplane being proposed for Accelerated ETOPS Operational Approval.
- (g) Any validation programme should address the following:
- (1) The operator should show that it has considered the impact of the ETOPS validation programme with regard to safety of flight operations. The operator should state in its application any policy guidance to personnel involved in the ETOPS process validation programme. Such guidance should clearly state that ETOPS process validation exercises should not be allowed to adversely impact the safety of operations especially during periods of abnormal, emergency, or high cockpit workload operations. It should emphasize that during periods of abnormal or emergency operation or high cockpit workload ETOPS process validation exercises may be terminated.
 - (2) The validation scenario should be of sufficient frequency and operational exposure to validate maintenance and operational support systems not validated by other means.
 - (3) A means must be established to monitor and report performance with respect to accomplishment of tasks associated with ETOPS process elements. Any recommended changes to ETOPS maintenance and operational process elements should be defined.
 - (4) Prior to the start of the process validation programme, the following information should be submitted to the CAA:
 - (i) Validation periods, including start dates and proposed completion dates.
 - (ii) Definition of aeroplane to be used in the validation. List should include registration numbers, manufacturer and serial number and model of the airframes and engines.
 - (iii) Description of the areas of operation (if relevant to validation objectives) proposed for validation and actual extended-range operations.
 - (iv) Definition of designated ETOPS validation routes. The routes should be of duration necessary to ensure process validation occurs.
 - (5) Process validation reporting. The operator should compile results of ETOPS process validation. The operator should:
 - (i) Document how each element of the ETOPS process was utilized during the validation.
 - (ii) Document any shortcomings with the process elements and measures in place to correct such shortcomings.
 - (iii) Document any changes to ETOPS processes that were required after an in-flight shutdown (IFSD), unscheduled engine removals, or any other significant operational events.
 - (iv) Provide periodic Process Validation reports to the CAA. This may be addressed during the Review Gates.
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