
CAP 513

Extended Range Twin Operations (ETOPS)

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Important Note

The CAA has made many of the documents that it publishes available electronically (in addition to traditional printed format). Where practical, the opportunity has been taken to incorporate a clearer revised appearance to the documents. Any significant changes to the content of this document will be shown in the Explanatory Note. If no such changes are indicated the material contained in this document, although different in appearance to the previously printed version, is unchanged. Further information about these changes and the latest version of documents can be found at www.caa.co.uk.

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Explanatory Note

1 Introduction

- 1.1 The CAA has made many of the documents that it publishes available electronically. Where practical, the opportunity has been taken to incorporate a clearer revised appearance to the document.
- 1.2 Due to regulation changes and the publication of JAA GAI20, CAP 513 will remain at Issue 3 and is to be used as guidance material only for older aircraft types. For all ETOPS operational and airworthiness requirements reference should be made to Joint Aviation Authorities Document GAI20 ACJ 20x6. Contact addresses, should you have any comments concerning the content of this document, are given on the inside cover of this publication.

2 Revisions in this Edition

- 2.1 The material contained in this document, although different in appearance to the previous version, is unchanged.

Amendment Record

Amendment Number	Amendment Date	Incorporated by	Incorporated on
Edition 3	11 October 2002		

Foreword

The development of the modern turbofan engine has made it possible to extend the range of twin-engined aeroplanes to allow some of them to fly great distances.

The problems that must be taken into account when planning flights over such distances include the availability of suitable airfields where a landing can be made in the event of an emergency occurring. Whereas in the past it was necessary for regulatory bodies to consider only aircraft with three or more engines when recommending safe operating standards and practices for long-range flights, it has now become necessary to include twins in the reckoning.

Because of the additional problems associated with the loss of a power unit or certain major systems on twin-engined aircraft, it is necessary, as a first step, to set a limit on the distance a twin may be from an adequate aerodrome without special requirements being imposed. This distance will be equal to one hour's flight time, in still air, at the normal one-engine-inoperative cruise speed. Any operation that is planned to involve flight by a twin-engined public transport aeroplane beyond this distance from an adequate aerodrome will be considered an Extended Range Operation.

The choice of sixty minutes is not arbitrary, but is a threshold which is:

- a) a maximum time compatible with the system capabilities of most existing twins, unless incorporating manufacturer's options to improve systems integrity;
- b) appropriate for new aeroplanes fitted with new engines which have not achieved operational maturity;
- c) an acceptable threshold which already exists in the legislation of some States. This CAP indicates the criteria by which extended range operations will be assessed. For the convenience of users, all matters relevant to extended range operations are included, and consequently there is some repetition of criteria already applicable to other types of operations. Extended range approval will be evidenced by a Permission specifically related to each operation.

1 Foreword to 3rd Edition

This edition has one amendment under Explanatory Note, Introduction, 1.2.

This amendment states that there will be no further amendments to this document and it is to be used as guidance material only, for older aircraft types.

Please read Explanatory Note, Introduction, 1.2 for further information.

Chapter 1 General

1 Purpose

This Civil Aviation Publication (CAP) states an acceptable means (but not necessarily the only means) by which approval may be given for UK-registered twin-engined aeroplanes to operate over a route that contains a point further than one hour's flying time (in still air) at the normal one-engine-inoperative cruise speed from an adequate aerodrome.

2 Applicability

2.1 The detailed requirements of this CAP will be applicable to all twin-engined aeroplanes (including those powered by turbo-props and reciprocating engines) which are flying for the purpose of public transport, and which meet both of the following criteria:

- a) the maximum authorised take-off weight exceeds 5700 kg; and
- b) the aeroplane is certificated to carry more than 19 passengers.

2.2 Although many of the requirements in this CAP are currently incorporated into an operator's approved programmes for other aeroplanes or route structures, the case of extended range operations with twin-engined aeroplanes necessitates an evaluation of these operations, to ensure that the approved programmes provide a level of safety broadly consistent with that achieved for current extended range operations with three and four-engined turbine powered aeroplanes. To be eligible for extended range operations, the specified airframe/engine combination should be evaluated by considering the concepts in paragraph 5 and meet the type design considerations in Chapter 2, the prerequisite in-service experience requirements of Chapter 3, and the continuing airworthiness and operational considerations in Chapter 4.

2.3 There may be existing operations which have been carried out regularly and safely over routes where the aeroplane is more than 60 minutes at the one-engine-inoperative speed from an adequate aerodrome. In such cases the operator should apply for clearance to continue such operations. The Authority may approve continuation of the operations on the basis of the proven safety record of the type, and of satisfactory operation over the route, in lieu of some of the detailed provisions of this CAP. Such approvals will be made on a case-by-case basis, and may be conditional on the applicant changing some of his maintenance or operational procedures, and reviewing the MEL for such flights. Where an operator ceases extended range operations for a period exceeding 13 months, the permission will lapse. It may be reinstated, subject to reassessment, on application.

3 Related Legislation and Requirements

- 3.1 Air Navigation Order (1989), Articles 6, 28, 30 and 35, and Schedule 4;
- 3.2 Air Navigation (General) Regulations (1981), Regulations 7 and 15, as amended;
- 3.3 JAR/ACJ 25.901, 25.903, 25.1309;
- 3.4 CAP 360 Parts 1 and 2;

3.5 CAP 418.

4 Definitions

4.1 Aerodrome

In general terms, an **operator** may make an appraisal that an aerodrome has long enough runways, and is sufficiently equipped, to be considered **adequate** for his planned ETOPS routes. The **commander** must satisfy himself on the day, using criteria provided by the operator, that he has sufficient **adequate** aerodromes which, taking into account the weather and any equipment unserviceabilities, are suitable for his intended operation. Definitions of **adequate** and **suitable** aerodromes, for the purpose of this CAP, are in Appendix B, paragraph 2. The use of the word **suitable** in this context may be different from its use in paragraph (1)(c) of Article 28 of the ANO.

4.2 Auxiliary Power Unit (APU)

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.

- a) An **essential** APU installation provides the bleed air and/or mechanical power necessary for the despatch of a transport category aeroplane for operations other than extended range operations with twin-engined aeroplanes.
- b) An APU installation **required** for extended range operations provides the bleed air and/or mechanical power necessary for the safe flight of a twin-engined 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.

4.3 Engine

The basic engine assembly plus its essential accessories as supplied by the engine manufacturer.

4.4 Extended Range Operations (ETOPS)

For the purpose of this CAP, extended range operations are those operations intended to be, or actually, conducted over a route that contains a point further than one hour's flying time (in still air) at the normal one-engine-inoperative cruise speed from an **adequate** aerodrome. When, alternatively, a Threshold Distance has been agreed with the Authority, all non-ETOPS flights shall remain within the Threshold Distance of an **adequate** aerodrome.

4.5 ETOPS Segment

The portion of an ETOPS flight that begins when the aeroplane is first more than Threshold Distance from any **adequate** aerodrome and ends when the aeroplane is last more than Threshold Distance from any **adequate** aerodrome.

4.6 Normal One-engine-inoperative Cruise Speed

For the purpose of this CAP, this cruise speed shall be the TAS specified in the ETOPS Airworthiness Approval in the Aeroplane Flight Manual, and agreed with the Authority and specified in the Company Operations Manual. If not otherwise specified, it shall be calculated from the single-engine, long range, cruise control data for the aeroplane, assuming that it:

- a) takes off at maximum authorised take-off weight; and

- b) climbs to and maintains the two-engined optimum initial cruise level for long range cruise, in ISA conditions, until two hours from take-off; and
- c) at its then current weight, in ISA conditions, with one engine shut down and the other at the power recommended for maximum continuous operation is flying level at a comfortably achievable maximum height and at the resultant stabilised speed.

4.7 **Powerplant**

A system consisting of an engine and all ancillary parts installed on the engine prior to installation on the aeroplane to provide and control power/thrust and for the extraction of energy. This does not include devices which produce thrust for short periods (i.e. Jet Assisted Take-off [JATO]).

4.8 **Rule Distance**

The distance travelled in still air in the Rule Time, at the normal one-engine-inoperative cruise speed.

4.9 **Rule Time**

The maximum diversion time that any point on the route may be from a suitable aerodrome for landing, as specified by the Authority and included in the Operations Manual.

4.10 **System**

A system 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 required to supply power for the equipment operation.

a) **Airframe System**

Any system on the aeroplane that is not a propulsion system.

b) **Propulsion System**

The aeroplane powerplant installation, including each component that: is necessary for propulsion; affects the control of the propulsion units; or affects the safety of the propulsion units.

4.11 **Threshold Distance**

The distance travelled in still air in 60 minutes by an aircraft at the normal one-engine-inoperative cruise speed.

4.12 **Threshold Time**

60 minutes.

4.13 **Unacceptable Thrust-Loss**

Total thrust loss, or loss of thrust to an extent that might affect continued safe flight.

5 **Concepts**

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 practices may invalidate certain assumptions made

during the aircraft 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 operations with twin-engined aeroplanes should also consider the probability of occurrence of any condition which would prevent the continued safe flight and landing, as well as the probability of occurrence of any condition which would reduce the capability of the aeroplane or the ability of the crew to cope with adverse operating conditions.

6 Considerations

- 6.1 A number of airframe and propulsion systems have an effect on the safety of extended range operations; therefore, the type design certification of the aeroplane will be reviewed, to ensure that the design of these systems is acceptable for the safe conduct of the intended operation.
- 6.2 In order to maintain a level of safety consistent with the overall safety level achieved by current aeroplanes used in airline service, it is necessary for twin-engined aeroplanes used in extended range operations to have an acceptably low risk of double propulsion system failure for all design and operations related causes. Additionally, in the event of a single propulsion system failure, the performance and reliability of the airframe systems, and of the remaining propulsion systems, should be sufficiently high to ensure a high probability of continued safe flight and landing at a suitable aerodrome.
- 6.3 Since the quality of maintenance programmes can have an appreciable effect on the reliability of the propulsion systems and the airframe systems required for extended range operation, an assessment will be made of the manufacturer's recommended and operator's proposed maintenance programme's ability to maintain a satisfactory level of systems reliability for the particular airframe/engine combination.
- 6.4 Flight crew workload and procedures in the event of system failures or malfunctions will be reviewed in the context of extended range operations. The normal certification assessment of the demands on the flight crew will be critically examined to ensure that the procedures can be accomplished by an average flight crew. In some cases, crew 'emergency' and 'abnormal' drills contained in the Aeroplane Flight Manual (AFM) and in the Operations Manual for an ETOPS approved aircraft may differ from those for a non-ETOPS approved aircraft. Where both drills are retained, they must be clearly identified and annotated as to the circumstances when they are to be used.
- 6.5 Following a determination that the airframe systems and propulsion systems are suitably designed for extended range operations, an in-depth review of the applicant's training programmes, operations, and maintenance programmes will be made to determine his ability to maintain an acceptable level of systems reliability in order to conduct these operations safely with the particular airframe/engine combination.
- 6.6 System redundancy levels appropriate to extended range operations will need to be reassessed and, where appropriate, reflected as revisions to minimum flight despatch configuration of the aeroplane (see Chapter 4, paragraph 4).

7 Approval Basis

7.1 General

For safe operations of twin-engined aeroplanes in extended range operations, it should be shown that the aeroplane is sufficiently reliable. This requires the systems relevant to extended range operations, including the propulsion system, to meet certification safety objectives in the conditions of the intended operations.

7.2 Type Design Approval

Evidence that the type design of the aeroplane is eligible for extended range operations is reflected by a statement in the CAA-approved AFM and Type Data Sheet.

7.3 In-service Experience Approval

In addition to the Type Design approval, it should be shown that the propulsion systems for that particular airframe/engine combination (world fleet) have achieved a sufficiently high level of reliability in-service so that safe extended range operations may be conducted. The achievement of this level of reliability is determined in accordance with Appendix A (see Chapter 3). It is also necessary for each operator desiring approval for extended range operations to show that sufficient maintenance and operations familiarity with that particular airframe/engine combination has been obtained (see Chapter 4).

7.4 Continuing Airworthiness and Operations Approval

Since the type design approval does not reflect a continuing airworthiness or operational approval to conduct extended range operation, each operator should demonstrate the ability to maintain the aeroplane so as to achieve the required reliability, and to train its personnel to achieve competence in extended range operations. The continuing airworthiness and operational approval to conduct extended range operations is made through the machinery of a permission (see Chapter 4).

Chapter 2 Type Design Approval Considerations

1 General

If a new twin-engined type design aeroplane is to be used in extended range operations, a determination should be made that the design features are suitable for the intended operation. In the event that an existing aeroplane's operation is expanded to include extended range operations, a re-evaluation of some design features may be necessary because of the greater exposure of the aeroplane in operations associated with twin-engined extended range operation. In this case, modifications to some systems may be necessary to achieve the desired reliability. In either case, the essential systems and the propulsion systems for the particular airframe/engine combinations should be shown to be **designed** to a level of reliability suitable for the intended maximum range operation of the aeroplane.

2 Criteria

The evaluation of failures and failure combinations should be based on engineering judgement and acceptable safety assessment methods. The analysis should consider effects of operations with a single engine, including allowance for damage 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 extension of range of aeroplanes with two engines:

- 2.1 Aeroplane systems should be shown to comply with JAR 25.1309 and the ACJs to 25.1309.
- 2.2 The propulsion systems should be shown to comply with JAR 25.901, ACJ 25.901, JAR 25.903 and ACJ 25.903.
- 2.3 Engineering and operational judgement applied in accordance with the assessment conditions outlined in Appendix A should be used to show that the propulsion system reliability has reached a level acceptable to the Authority for extended range operation, due account being taken of the still-air intended flight duration and mean diversion time to a **suitable** alternate. This determination of the propulsion system reliability is derived from a worldfleet database containing all in-flight engine shutdown occurrences, all significant engine reliability problems, and available data on cases of significant loss of thrust. This determination also includes the appropriate accounting for the rectification of the identified engine design problems, as well as occurrences where in-flight starting capability may be a significant factor.
- 2.4 The safety impact of an uncontained engine failure should be reassessed in accordance with JAR 25.903 having due regard to both the Rule Time and system status allowed under the minimum flight despatch configurations of the aeroplane.
- 2.5 The APU installation, if required for extended range operations, should meet the applicable JAR-APU provisions, and the requirements of JAR 25.1309.
- 2.6 For extended duration single-engine operations (considering the resulting degradation on the performance of the aeroplane type), any increase in workload and the adverse effects of malfunctions of remaining systems and equipment on flight crew

procedure should be minimised, and should be within the capabilities of an average flight crew.

- 2.7 For extended duration single-engine operation, remaining power (electrical, hydraulic, pneumatic) should continue to be available at levels necessary to permit continued safe flight and landing and to provide those services required for the overall safety of the passengers and crew.
- 2.8 In meeting the requirements of the ANO Schedule 4 Scale L1 or L2 (as applicable), unless it can be shown that normal cabin pressure can be maintained on single engine operation at the altitude required for continued flight to a **suitable** aerodrome, oxygen should be available to sustain the passengers and crew for the maximum diversion time.
- 2.9 A sufficient number of reliable, independent electrical power sources should be available to meet the requirements of JAR 25.1309; this is likely to require at least three power sources. As a minimum, each electrical source should be non-time limited and be capable of powering the items specified in paragraphs 3.4 and 3.7. If one or more of the required electrical power sources are powered by (i) an APU, (ii) a hydraulic system, or (iii) a ram air turbine, the following criteria apply respectively:
- The APU, when installed, should meet the requirements of JAR-25, Sub-part J, together with any additional criteria arising from paragraph 2.5 above. It should be shown that there is a very high probability that, after the failure of any one or two generated sources of power, the APU can be started without delay at any altitude up to and including the aeroplane's certificated altitude. If this condition cannot be met, the APU will have to be kept running throughout the ETOPS segment unless the Authority agrees otherwise. Other requirements may be specified by the Authority after their review of the applicant's data;
 - The hydraulic power source should be driven by two or more independent energy sources, and at least one should continue to be available in the event of failure of either engine and/or both main generators; e.g. bleed-air driven pump and RAT;
 - Ram air turbine deployment should be demonstrated to be sufficiently reliable and not require main electrical or engine-dependent power for deployment.
- NOTE:** 1 Following the loss of all normal generated electrical power, continuity of electrical power for essential service (e.g. by use of batteries) should be assured until the non-time limited emergency or standby power source can be brought into operation.
- NOTE:** 2 If loss of all engines can prevent the operation of the non-time limited power source, emergency or standby, sufficient battery capacity should be provided to allow a controlled descent and emergency alighting.
- 2.10 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, avionics, communications, navigation, required route or destination guidance equipment, support systems and/or hardware, and any other equipment deemed necessary for extended range operation, to continue safe flight and landing at a **suitable** aerodrome. Information provided to the flight crew should be of a sufficient accuracy for the intended operation.
- 2.11 Communications facilities for updated diversion weather; indications of residual systems capabilities; and crew procedures, should all be such that the flight crew

have the necessary information to make decisions on diversion at any point on the route.

- 2.12 Extended range operations are not permitted where any time limited system, that is essential for continued safe flight and landing has a minimum endurance that is less than the intended Rule Time, plus a 15 minute allowance for approach and landing at a suitable aerodrome, e.g. a cargo compartment fire suppression system.
- 2.13 If enhanced scheduled maintenance, replacement, and/or inspection are utilised to obtain type design approval for extended range operation, then the specified maintenance should be clearly identified in an appropriate approved maintenance manual and schedule.

3 Analysis of Failure Effects and Reliability¹

3.1 General

The analysis and demonstration of system failure effects and reliability should be based on the maximum declared endurance of the aeroplane used in extended range operation.

3.2 Propulsion Systems

- a) An assessment of the propulsion systems reliability for particular airframe/engine combinations will be made in accordance with Appendix A.
- b) The analyses will review, in the context of extended range operations, the effects of operation with a single propulsion system, including probable damage that could result from failure of the first engine. Effects of failures, external conditions, or crew errors, that could jeopardise the operation of the remaining propulsion system under single power unit operating conditions, will be examined.

NOTE: Consideration should be given to any adverse effect of electrical failure on the aeroplane fuel supply system e.g. loss of fuel boost and transfer pumps.

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 primary flight controls hydraulically powered, evaluation of hydraulic system redundancy should include a determination of the ability to maintain continued safe flight and landing after the complete loss of any two hydraulic systems and either engine, unless it can be shown that such a combination of events is Extremely Improbable.

3.4 Electrical Power

Electrical 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 flightcrew to cope effectively with adverse operating conditions. Multiple sources (engine-driven generators, APUs, etc.) should be provided to meet both the 'continued safe flight and landing requirements' and the 'adverse conditions requirements'. The analysis should establish that electrical power can be maintained to essential instruments and other services for continued safe flight and landing, and to allow the flight crew to cope with adverse operating conditions. When re-assessing the aeroplane against the requirements of JAR 25.903(d)(1) and its ACJ as noted in paragraph 2.4 above, it should be demonstrated

1. The probability terms used within this paragraph are defined in ACJ No. 1 to JAR 25.1309.

that the design of the system is such that the risk of losing all non-time limited power sources has been minimised.

3.5 **Equipment Cooling**

The analysis should establish that the required 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 despatch and during flight.

3.6 **Cargo Compartment**

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

a) **Design**

The cargo compartment fire protection system integrity and reliability should be suitable for the intended operations, considering fire detection sensors, liner materials, etc.

b) **Fire Protection**

A test or a combination of analysis and tests should be made to show that, considering the time required to terminate an extended range operation, the ability of the system to suppress or extinguish fires is adequate to assure safe flight and landing at a suitable aerodrome.

3.7 **Communication, 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 required route and destination guidance needed to comply with contingency procedures for extended range operation, will be available.

3.8 **Cabin Pressurisation**

It should be shown that as a result of general system redundancy and 'fail safe' features of the system, the loss of cabin pressure is Improbable under single engine operating conditions. Aeroplane performance data should be provided to verify the ability to continue safe flight and landing after loss of pressure and subsequent operation at a lower altitude (see also Chapter 4, paragraph 4.6.).

3.9 **Modifications**

All modifications proposed for embodiment to ETOPS configured aircraft/engines, subsequent to Type Certification, must be assessed for their possible effect on such operations (see also Chapter 4, paragraph 3.1.)

4 Assessment of Failure Conditions

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

4.1 The variations in the performance of the system, the probability of the failure(s), and the complexity of the crew action.

4.2 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.

5 Type Design Approval

- 5.1 Upon satisfactory completion of an evaluation an extended range operation type design approval will be issued.
- 5.2 The type design approval is normally reflected in the CAA-approved AFM or supplement, and Type Certification Data Sheet, which will contain the following pertinent information, as applicable:
- a) Special limitations relating to ETOPS operation;
 - b) Markings or placards (if required);
 - c) Revision to the performance section (if required);
 - d) The airborne equipment, installation, and flight crew procedures required for extended range operations;
 - e) Description of the approved aeroplane configuration;
 - f) A statement to the effect that: 'The type design reliability and performance of this airframe/engine combination has been evaluated in accordance with CAP 513 and found suitable for extended range operations with maximum diversion time not exceeding **xxx** minutes as limited by the capability of **yyy** system. This finding does not on its own constitute approval to conduct extended range operations.'

NOTE: The Rule Time will not normally exceed a figure that is 15 minutes less than the nominal endurance of any time-related required system.

6 Type Design Monitoring

The Basic Certification Authority for the aeroplane and for the engine will monitor the continued airworthiness in extended range operations, and will identify any significant problems through the normal airworthiness directive process for the approved type design. Where the Basic Certification Authority is not within the JAR system, suitable arrangements will need to be made.

Chapter 3 In-service Experience

1 Worldwide Experience

- 1.1 In addition to substantiating a type design in accordance with Chapter 2 of this CAP, and as a prerequisite to obtaining continuing airworthiness/operational approval in accordance with the criteria of Chapter 4 of this CAP, 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.
- 1.2 Subsequent to the type design approval, it should be shown that the **world fleet** of the particular airframe/engine combination for which approval is sought has achieved, as determined by the CAA, an acceptable and reasonably stable level of single propulsion system inflight shutdown (IFSD) rate necessary for extended range operation. When considering the acceptability of a propulsion system for extended range operations, maturity should be assessed not only in terms of total fleet hours but also to take account of fleet leader time. In order that the assessment can be made with confidence, the minimum requirement should comprise both **world fleet** hours and calendar time. There is justification for the view that modern propulsion systems achieve a stable reliability level by 100 000 hours for new types and 50 000 hours for derivatives. 3000 to 4000 hours is considered to be the minimum time in service for a specific unit to indicate problem areas. The minimum service experience required will be for new propulsion systems, 100 000 hours and 12 months service, for derivative propulsion systems, 50 000 hours and 12 months service. The latter may vary according to the degree of commonality. The determination of propulsion system reliability is derived from a **world fleet** database, containing all in-flight engine shutdown events for all design and operations related causes during all phases of flight, significant engine reliability problems, and the available data on cases of significant loss of thrust, including those where the engine failed or was throttled back/shutdown by the pilot, except where throttling back is required by operational procedures.
- 1.3 Engineering judgement applied in accordance with the assessment considerations outlined in Appendix A will then be used to establish that the probability of dual engine failure for all independent causes in cruise of 0.3×10^{-8} per hour or less can be achieved. This assessment is in addition to the determination in Chapter 2, paragraph 2.2 for type design approval, and will take due account of the diversion time to a **suitable** aerodrome, rectification of identified propulsion system problems, as well as events where inflight starting capability may be a significant factor.

2 Specific Operator Experience

Each operator requesting approval will be required to have appropriate experience. A summary shall be provided to the Authority, indicating the operator's capability to maintain and operate the specific airframe/engine combination for the intended extended-range operation. This summary should include: experience with the engine type or related engine types, experience with the aeroplane systems or related aeroplane systems, and experience with the particular airframe/engine combination on non-extended range routes. Approval would be based on a review of this information.

NOTE: Not less than 12 consecutive months experience with the specified airframe/engine combination will normally be required, unless the operator can show

extensive in-service experience with a related power unit on another aeroplane which has achieved good reliability. However the operator will still need, in the latter case, to demonstrate his capability to maintain and operate the new airframe/engine combination at a similar level of reliability.

Chapter 4 Operational Approval Considerations

1 General

Any operator requesting approval for extended range operations with twin-engined aeroplanes (after providing evidence of an acceptable evaluation of the considerations in Chapters 2 and 3) should submit the requests with the required supporting data, to the Authority, at least 60 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 will 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 to safely conduct and support these operations, and should include the considerations outlined in this Chapter. Any reliability assessment obtained, either through analysis or service experience, will be used as guidance in support of operational judgements regarding the suitability of the intended operation.

2 Assessment of the Operator's Propulsion System Reliability

Following the accumulation of adequate operating experience by the world-wide fleet of the specified airframe/engine combination, and the establishment of an IFSD rate in accordance with Chapter 3 and approved in accordance with Appendix A for use in assuring the propulsion system reliability required for extended range operations, an assessment will be made of the applicant's ability to maintain this level of propulsion system reliability. This assessment will include trend comparisons of his data with other operators as well as the **world fleet** average values, and the application of a qualitative judgement that considers all of the relevant factors. The operator's past record of propulsion system reliability with related types of power units will also be reviewed, as well as his record achieved with the airframe/engine combination for which authorisation is sought to conduct extended range operations.

3 Engineering Modifications and Maintenance Programme Considerations

Although these considerations are normally part of the operator's continuing airworthiness programme, the following items will be reviewed to ensure that these programmes are adequate for extended range operations:

3.1 Engineering Modifications

A summary of the titles and numbers of all modifications, additions and changes which were made to qualify airframe and propulsion systems for extended range operations should be provided to the Authority. Details of any non-manufacturer modifications introduced for initial operation by an operator should also be submitted to the Authority for an assessment to be carried out of their possible effect on extended range operation. All modifications proposed for subsequent embodiment to ETOPS configured aircraft/engines should be assessed for their possible effect on this operation. The assessment should be conducted by the operator in consultation with the appropriate constructor (see Chapter 2, paragraph 3.9.).

3.2 Maintenance and Training Procedures

Maintenance and training procedures, practices and limitations established for extended range operations should be submitted to the Authority for approval. Any

subsequent changes to these arrangements should be submitted to the Authority for acceptance 30 days before such changes are adopted.

3.3 **Reliability Reporting**

A reliability reporting programme should be developed and implemented prior to approval and continued after approval. Appendix C contains additional information concerning reliability reporting. Regular reports, in terms of both reliability trends and occurrences, should be directed to both the Authority and the manufacturer.

3.4 **Modifications and Inspections**

There should be procedures for the prompt implementation of modifications and inspections which could affect propulsion system and airframe system reliability.

3.5 **Aircraft Despatch**

Procedures should be established which would preclude an aeroplane being despatched for extended range operation after power unit shutdown or primary system failure on a previous flight, or significant adverse trends in system performance, unless appropriate corrective action has been taken. Confirmation of such action as being appropriate may, in some cases, require the successful completion of a subsequent flight prior to despatch on an extended range operation.

3.6 **Maintenance Programme**

The operator's maintenance programme should ensure that the aircraft, engine and equipment will continue to be maintained at the level of performance and reliability required for extended range operations.

Any maintenance requirement which has been enhanced to support type design approval should be identified in the programme and may not be varied without the approval of the Authority.

3.7 **Engine Condition Monitoring**

An engine condition monitoring programme should be developed which may include hard time inspection intervals for component condition which is not otherwise observable and which could adversely affect failure rates.

3.8 **Oil Consumption**

There should be an engine and APU (where appropriate) oil consumption monitoring programme.

4 **Flight Despatch Considerations**

4.1 **General**

The flight despatch considerations specified herein are in addition to, or amplify, the requirements contained in Article 35 of the Air Navigation Order, and specifically apply to extended range operations. Although many of the considerations in this CAP are currently incorporated into approved procedures for other aeroplanes or route structures, the nature of ETOPS necessitates a re-examination of these operations, to ensure that the approved procedures are adequate for this purpose.

4.2 **Minimum Equipment List (MEL)**

Primary system redundancy levels appropriate to extended range operations will be reflected in the MEL or ADL. For aeroplanes already in operational service, the existing MEL will be re-evaluated and adjusted appropriately, to reflect primary system redundancy levels necessary for extended range operations. Primary airframe

systems are considered to be those systems which have a fundamental influence on flight safety and could be adversely affected by the shutdown of a power unit. Such systems may include, but are not limited to:

- 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;
- o) Engine fire detection and extinguishing systems; and
- p) Any other equipment required for extended range operations.

4.3 **Communication and Navigation Facilities**

An aeroplane shall not be despatched on an extended range operation unless:

- a) Communications facilities are available to provide, under all expected 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; and
- 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 required over the planned route and altitude of flight, and the routes to any alternate and altitudes to be used in the event of diversion for whatever reason; and
- c) Approved visual and non-visual aids are available at the specified alternates for the authorised types of approaches and operating minima.

4.4 **Fuel and Oil Supply**

a) **General**

An aeroplane shall not be despatched on an extended range flight unless it carries sufficient fuel and oil to meet the requirements of the Air Navigation Order, as amplified in CAP 360 Part 1; and in addition, such additional fuel and oil as may be required to fly to a **suitable** aerodrome for landing in the event of the shutdown of an engine, or in the event of airframe system failure(s), which may require diversion to an alternate. It should be assumed that this event occurs at the most critical point in terms of overall fuel and oil requirements along the planned route of flight.

b) Critical Fuel Scenario

The following describes the assumptions to be used in determining the fuel reserve required to cover the en-route diversion case. The operator should confirm that this scenario is operationally the most critical, having considered also the possibilities of no engine failure but total pressurisation failure, and no pressurisation failure but one engine failure.

- i) At that particular critical point, consider simultaneous failure of an engine and the pressurisation system; (critical point based on time to a **suitable** alternate at the one-engine-inoperative cruise speed, for existing conditions, using forecast winds at the appropriate flight level).
- ii) Immediate descent to and continued cruise at 10 000 feet at the relevant one-engine-inoperative cruise speed (or above 10 000 feet if the aeroplane is equipped with sufficient supplemental oxygen in accordance with the Air Navigation Order (1989), Schedule 4, Scale L1).
- iii) When approaching the diversion aerodrome, descend to 1500 feet above destination, hold for 15 minutes, initiate an approach followed by a missed approach, and then continue to a normal approach and landing.
- iv) Unless the operator has an established value for in-service deterioration in cruise fuel mileage, the fuel calculated under (i) and (ii) above should be increased by 5 per cent.

c) Fuel Planning Considerations

In computing fuel and oil requirements, advantage may be taken of driftdown, where appropriate, and at least the following should be considered as applicable:

- i) Current forecast winds and meteorological conditions along the expected flight path at the one-engine-inoperative cruising altitude and throughout the approach and landing; to allow for errors in wind forecasts and navigation, a contingency figure of 5 per cent should be added to calculated fuel burn from the critical point of Chapter 4, paragraph 4.4 a);
- ii) Any Configuration Deviation List items;
- iii) Any necessary operation of ice protection systems, and any performance loss due to ice accretion on unheated surfaces of the aeroplane, if icing conditions are likely to be encountered during the diversion.
- iv) Any necessary operation of an auxiliary power unit and/or RAT;
- v) Any known Air Traffic Control constraints.

4.5 Alternate Aerodromes

An aeroplane should not be despatched 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 power-unit shutdown or 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 ATC flight plan and the despatch release (if applicable) for all cases where the planned route of flight contains a point more than one hour's flying time at the one-engine-inoperative speed from an **adequate** aerodrome. Since these **suitable** en-route alternates serve a different purpose from the destination alternate aerodrome, and would normally be used only in the event of an engine failure or the loss of primary airframe systems, an aerodrome should not be listed as a **suitable** en-route alternate unless:

- a) 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 Regulation 7 of the Air Navigation (General) Regulations;
- b) The aerodrome services and facilities are adequate for the operator's approved approach procedure(s) and operating minima for the runway expected to be used;
- c) 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 that aerodrome, equal or exceed the Planning Minima for alternate aerodromes in the AOC holder's operations manual, calculated in accordance with Appendix V; and
- d) 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 that aerodrome, the forecast crosswind component, including gusts, for the intended landing runway is less than the maximum permitted crosswind for landing, with one engine inoperative.

4.6 **Aeroplane Performance Data**

No aeroplane should be despatched on an extended range flight unless the Operations Manual contains:

- a) Detailed one-engine-inoperative performance data covering:
 - i) Drift-down;
 - ii) Cruise (altitude coverage including 10 000 feet);
 - iii) Holding;
 - iv) Altitude capability;
 - v) Missed approach; and
- b) Details of any other conditions relevant to extended range operations which can cause significant deterioration of performance, such as ice accretion on the unheated surfaces of the aeroplane; Ram Air Turbine (RAT) deployment; etc.

5 **Flight Crew Training and Evaluation Programme**

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

5.1 **Performance:**

- a) Flight planning, including all reasonably probable foreseeable contingencies;
- b) Flight performance progress monitoring.

5.2 **Procedures:**

- a) Diversion procedures;
- b) Use of appropriate navigation and communication systems;
- c) Abnormal and emergency procedures to be followed in the event of foreseeable failures, including:

- i) Procedures for single and multiple in-flight equipment failures that would require flight to the nearest suitable aerodrome;
 - ii) Operational restrictions associated with these failures;
 - iii) Procedures for airborne start of the propulsion systems, including the APU, if required;
 - iv) Crew incapacitation;
- d) Use of the ETOPS MEL, and Despatch Deviation Guide, if applicable;
 - e) Use of emergency equipment, including protective breathing and ditching items;
 - f) Understanding and effective use of approved additional or modified equipment required for extended range operations.

5.3 Refresher Training

In addition to initial training given to crew members, operators should arrange an annual refresher programme in order to ensure that the level of awareness on matters relating to extended range operations is kept at a satisfactory level. Such refresher training must include a written test paper and may include items in the bi-annual simulator exercises where appropriate.

6 Operational Limitations

6.1 Area of Operation

An operator may be authorised to conduct extended range operations with a particular airframe/engine combination within a particular area (e.g. N Atlantic) where the maximum diversion time, from any point along the proposed route of flight to an adequate aerodrome, is up to 180 minutes or less (as specified by the Authority) at the normal one-engine-inoperative cruise speed (under standard conditions, in still air). The particular areas will be specified on the permission issued by the regulatory Authority for the purpose of approving extended range operations.

6.2 Operations Manual Instructions

Operations Manual instructions should specify the maximum diversion time from a suitable aerodrome to be used when planning a particular extended range operation. The maximum diversion time in still air at the normal one-engine-inoperative cruise speed cannot be any greater than that established by paragraphs a) and b) of this section. Authorisation for operations beyond these values will not be permitted until operational experience, in extended range operations with twin-engined aeroplanes, clearly indicates that further credit is appropriate.

a) Use of Standard Maximum Diversion Time

The Operations Manual instructions should ensure that extended range operations are limited to flight plan routes where a maximum diversion time of 120 minutes or less at the normal one-engine-inoperative cruise speed in still air to **suitable** aerodromes can be met. Operators should also give instructions that:

- i) Upon occurrence of an in-flight shutdown of an engine, the pilot should fly to and land at the nearest **suitable** aerodrome, under the prevailing conditions, at which a safe landing can be made; and
- ii) In the event of a single or multiple primary system failure, the pilot should fly to and land at the nearest **suitable** aerodrome, under the prevailing conditions,

unless it has been demonstrated that no substantial degradation of safety results from continuation of the planned flight.

b) Increased Maximum Diversion Time

Although still constrained by the area of operation authorised in accordance with Chapter 4, paragraph 6.1, those operators who also choose to demonstrate all or some of the additional capabilities discussed in this section may be approved, on a case by case basis, for an increase in diversion time from a suitable alternate. Six months satisfactory operations is required at 120 minutes in order to increase maximum Rule Time up to 138 minutes. An increase beyond 138 minutes Rule Time (e.g. to a maximum of 180 minutes) may be approved provided all items in subparagraphs i) to vi) below are complied with.

i) Special Maintenance Practices and Procedures

which result in the operator's engine in-flight shutdown rate being significantly better than the minimum level required for the maximum diversion time for the particular airframe/engine combination, and achieve a very low number of carried forward defects by thorough and timely action on maintenance discrepancies.

ii) Special Operating Practices and Procedures

for use of such items as: Category 2/3 authorisation, special MEL provisions, communications links for weather dissemination, and pre-planned contingency actions, based on current data for each ETOPS flight, for at least the five most probable operating contingencies, including engine and airframe system failures.

iii) Special Crew Training

which includes procedures for use in all appropriate operating contingencies, and other special qualifications such as Category 2/3, and navigational practices such as point of no return/radius of action (unless computerised on-board navigation systems suffice).

iv) Special Equipment

which would enhance the capabilities of the aeroplane and flightcrew in extended range operation. Examples are: approved Category 2/3 capability, flight management computers which would provide readily accessible range, performance, and navigation information to all required alternate aerodromes, VHF/HF/satellite data link equipment to enhance reliability and timeliness of communications.

v) One year's satisfactory and extensive operations at a maximum rule time of not more than 138 minutes in order to increase maximum rule time up to 180 minutes.

vi) Any additional restrictions the Authority may seek to impose.

6.3 Contingency procedures or plans should not be interpreted in any way which prejudices the final authority and responsibility of the pilot-in-command for the safe operation of the aeroplane.

7 Operations Manual

- 7.1 The Operations Manual must make it clear that without the appropriate and relevant Permission, Extended Range Operations are not authorised and may not be conducted.
- 7.1.1 Information in the operations manual for extended range operations should specifically include provisions covering at least the following:
- a) Designation of the particular airframe/engine combination, including specification of modifications required for extended range operation;
 - b) Approved area of operation, and all relevant ATC requirements;
 - c) Minimum altitudes to be flown along planned and diversionary routes, and maximum altitudes if restricted by ETOPS considerations (e.g. APU start capability);
 - d) Rule Distance;
 - e) The power settings, speeds, and flight levels to be used after the failure or shut-down of an engine;
 - f) Aerodromes authorised for use, including alternates and associated instrument approaches, operating minima, and planning minima (see Appendix B);
 - g) A clear statement that it is the commander's responsibility not to accept ATC clearances that would take the aeroplane outside the approved ETOPS envelope in terms of Rule Distance and Flight Level;
 - h) Reference to the approved maintenance schedule requirements for extended range operations, including those items specified in the type design approval of the ETOPS variant;
 - i) Identification of those aeroplanes designated for extended range operations by make and model, as well as by serial number and registration letters.
 - j) Minimum crew qualifications and recency to allow them to operate unsupervised on extended range flights.
 - k) Guidance on minimum acceptable system and equipment levels of serviceability in order to continue an extended range operation in the event of an in-flight failure. Full information should be provided as and when a flight may continue in these circumstances at the normal or at a reduced Rule Distance from suitable alternate.
 - l) Procedures to enable the flight to be conducted on an alternative rule as 'non-ETOPS', i.e. not more than 60 minutes from a suitable alternate. Otherwise a statement in the Operations Manual that non-ETOPS flights are not approved on that route.

8 Operational Validation

The operator should demonstrate that he has the competence and capability to safely conduct and adequately support the intended operation. A validation flight, in the aeroplane or an approved simulator, should also incorporate a demonstration of the most critical of the following emergency conditions:

- 8.1 Total loss of thrust of one engine; and
- 8.2 Total loss of engine-generated electrical power, or any other condition considered to be equivalent in airworthiness, crew workload, or performance risk.

9 Extended Range Operations Approval

Following a type design approval for ETOPS, and satisfactory application of the other criteria in this CAP, including a validation flight or acceptable simulation, an operator may be authorised to conduct extended range operations with twin-engined aeroplanes through the machinery of a Permission.

10 Provision of Operating Data

Operators should collate data in order to provide statistics to the Flight Operations Department of the Authority for each year ending 31 December. The following information should be provided:

- a) Number of extended range flights operated in the year.
- b) Incidents experienced which were relevant to extended range operations.
- c) Details of any diversion from an extended range operation.
- d) The number of occasions (with details) when flights were not despatched on extended range operations due to aircraft unserviceability or weather below planning minima at the available adequate alternates.

11 Retention of Operating Data

Operators should review their ETOPS operations in order to ensure that their flights are despatched and operated in accordance with the Operations Manual procedures. To facilitate this, as a minimum, the meteorological data and other aeronautical information used by the crew at the despatch stage should be retained for three months after the date of the flight.

Chapter 5 Continuing Surveillance and Engine Reliability Report

1 Continuing Surveillance

The fleet average In Flight Shut Down (IFSD) rate for the specified airframe/engine combination will continue to be monitored in accordance with Appendix A. As with all other operations, the Authority will monitor all aspects of the extended range operations it has authorised, to ensure the levels of reliability achieved in extended range operation remain at the necessary levels, and that the operation continues to be conducted safely. In the event that an acceptable level of reliability is not maintained, or if significant deficiencies are detected in the conduct of operations, the Authority will require the operator to take all necessary action to resolve the problems in a timely manner, or will withdraw the authorisation for extended range operations.

2 Engine Reliability Report

A propulsion system reliability report will be published, providing the results of the assessment of the **world fleet** engine reliability as it relates to design and operations for a particular airframe/engine combination. This will be done in accordance with Appendix A.

Appendix A Propulsion System Reliability Assessment and Report

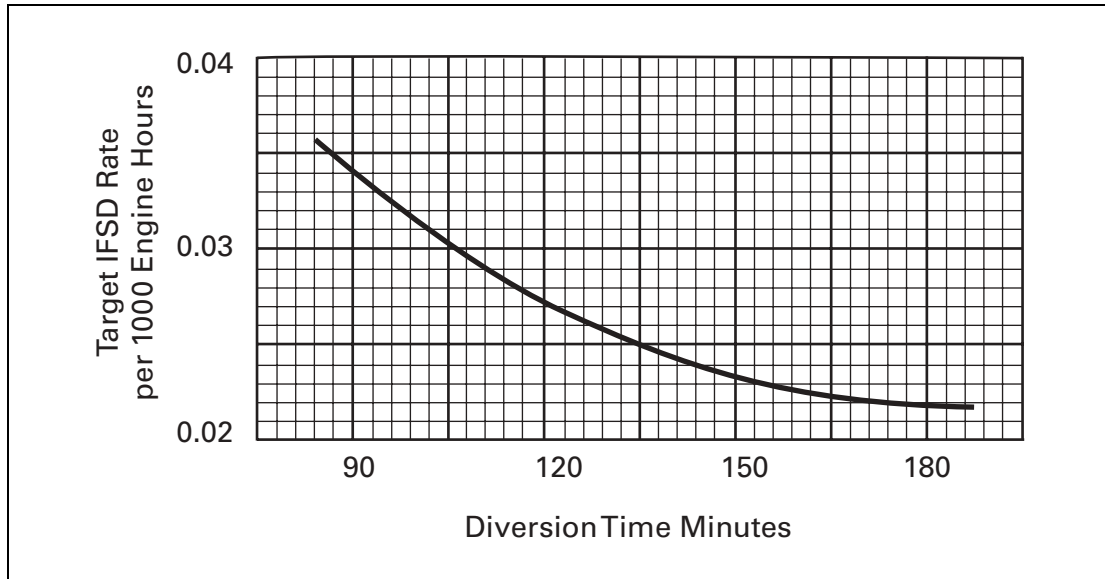
1 General

- 1.1 To establish whether a particular airframe/engine combination has satisfied the propulsion systems reliability requirements for extended range operations, an assessment will be made by the Authority, using all pertinent engine and propulsion systems data. To accomplish the assessment, the Authority will need **world fleet** data, and data from various sources (the operator, the engine manufacturer and the aeroplane manufacturer) which should be extensive enough and of sufficient maturity to enable the Authority to assess with a high level of confidence, using engineering and operational judgement and standard statistical methods where appropriate, that the risk of total power loss from independent causes is low enough. The Authority will state whether or not the current propulsion system reliability of a particular airframe/engine combination satisfies the relevant criteria. Included in the statement, if the operation is approved, will be the engine build standard, propulsion system configuration, operating condition and limitations required to qualify the propulsion system as suitable for extended range operation.

2 Concepts

2.1 Risk Management and Risk Model

Propulsion systems approved for extended range operations must be sufficiently reliable to assure that defined safety targets are achieved. A review of information for modern fixed wing jet powered aircraft over a recent six year period shows that the rate of fatal accidents for all causes is in the order of 0.3×10^{-6} per flying hour. The reliability of aircraft type approved for extended range operations should be such that they achieve at least as good an accident record as equivalent technology equipment. The overall target of 0.3×10^{-6} per flying hour has therefore been chosen as the all causes safety target. When considering safety targets, an accepted practice is to allocate appropriate portions of the total to the various potential contributing factors. By applying this practice to the overall target of 0.3×10^{-6} per flying hour, in the portions previously considered appropriate, the probability of a catastrophic accident due to complete loss of thrust for independent causes must be no worse than 0.3×10^{-8} per flying hour. Loss of all thrust may result from not only independent cause events but from uncontained engine failure events, common cause events, engine failure plus crew error events, human error related events and others. The majority of these factors are not specially associated with ETOPS. Using an expression developed by ICAO for the calculation of engine in-flight shutdown rate, together with the above safety objective and accident statistics, a relationship between target engine in-flight shutdown rate for all causes and diversion time has been derived. This is shown in Table 1. In order that type design approval may be granted for extended range operations, it will be necessary to satisfy the Authority that after application of the corrective actions identified during the engineering assessment (see Appendix A, paragraph 3), the target engine in-flight shutdown rates will be achieved. This will provide assurance that the probability objective for loss of all thrust due to independent causes will be met.

**Table 1**

2.2 Data Requirements

- a) A list of all engine shutdown events, both ground and in-flight, for all causes (excluding normal training events) including flameout. The list should provide the following for each event: date, airline, aeroplane and engine identification (model and serial number), power unit configuration and modification history, engine position, symptoms leading up to the event, phase of flight or ground operation, weather/environmental conditions and reason for shutdown, any comment regarding engine re-start potential.
- b) All occurrences where the intended thrust level was not achieved, or where crew action was taken to reduce thrust below the normal level, for whatever reason.
- c) Unscheduled engine removals/shop visit rates.
- d) Total engine hours and aeroplane cycles.
- e) Mean time between failure of propulsion system components that affect reliability.
- f) Additional data as required.

3 Engineering Assessment

- 3.1 There are maintenance programmes, engine on-wing health monitoring programmes, promptness and completeness in incorporating engine service bulletins, etc, that influence an operator's ability to maintain a level of reliability. The data and information required will form a basis from which a **world-fleet** engine shutdown rate will be established for use in determining whether a particular airframe/engine combination complies with criteria for extended range operation.
- 3.2 An analysis will be made on a case by case basis, of all significant failures, defects and malfunctions experienced in service (or during testing) for the particular airframe/engine combination. Significant failures are principally those causing or resulting in in-flight shutdown or flameout of the engine(s), but may also include unusual ground failures and/or unscheduled removal of engines. In making the assessment, consideration will be given to the following:

- a) The type of power unit, previous experience, whether the power unit is new or a derivative of an existing model, and the engine operating thrust level to be used after one-engine shutdown.
 - b) The trends in cumulative and three and twelve month rolling average, updated quarterly, of in-flight shutdown rates versus propulsion system flight hours and cycles.
 - c) The demonstrated 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 conditions likely to be encountered.
 - f) Intended maximum flight duration, and maximum diversion and mean diversion time in the ETOPS segment, used in the extended range operation under consideration.
- 3.3 Engineering judgement will be used in the analysis of paragraph 3.2 such that the potential improvement in reliability, following the introduction of corrective actions identified during the analysis, can be quantified.
- 3.4 The resultant predicted reliability level and the criteria developed in accordance with paragraph 2.1 will together be used to determine the maximum diversion time for which the particular airframe/engine combination qualifies.
- 3.5 The type design standard for type approval of the airframe/engine combination for extended range operation will include those modifications and maintenance actions for which credit is taken in paragraph 3.3, and such other actions required by the Authority to enhance reliability.
- 3.6 When a foreign manufacturer's and/or operator's data are being evaluated, the respective foreign Airworthiness Authorities will be offered the opportunity to participate in the assessment.

Appendix B En-Route Alternate Aerodromes

1 General

- 1.1 One of the distinguishing features of extended range twin-engined operations is the concept of a **suitable** (see paragraph 2 below) en-route alternate being available, to which an aeroplane can divert after a single failure or failure combinations which require a diversion. Whereas most twin-engined aeroplanes operate in an environment where there is usually a choice of diversions available, the ETOPS aeroplane may have only one aerodrome 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.
- 1.2 It is, therefore, important that any aerodromes designated as en-route alternates should have the capabilities, services, and facilities to safely support that particular aeroplane. The weather conditions at the time of arrival should provide a higher than normal assurance that adequate visual reference will be available upon arrival at decision height (DH) or minimum decision altitude (MDA), and the surface wind conditions and corresponding runway surface conditions should be within acceptable limits to permit the approach and landing to be safely completed with an engine inoperative. These considerations shall apply to all aerodromes which are considered as alternates when flying the ETOPS segment, thus possibly including the departure and/or destination airfields.
- 1.3 Designated alternates and all their associated performance and planning data should be specified in the Operations Manuals.

2 Definitions of Aerodromes

2.1 Adequate

For the purpose of this CAP, an **adequate** aerodrome is an aerodrome which the operator of the aircraft considers to be adequate, having regard to his responsibilities pursuant to Article 28(1)(c) of the Air Navigation Order (1989) and Regulations 7 and 15 of the Air Navigation (General) Regulations (1981). In particular, it should be expected that at the anticipated time of use:

- a) the aerodrome will be available, and equipped with necessary ancillary services, such as ATC, sufficient lighting, communications, weather reporting, nav aids, and safety cover; and
- b) at least one letdown aid (ground radar would so qualify) will be available for an instrument approach.

2.2 Suitable

For the purpose of this CAP, a **suitable** aerodrome is an **adequate** aerodrome where, at the anticipated time of use, weather reports, or forecasts, or any combination thereof, indicate that the weather conditions are very likely to be at or above the normal operating minima at the time of the intended operation, using the criteria set out in this Appendix. Where a condition is forecast as 'Prob.', provided the probability per cent factor is less than 40 per cent, then that condition can be ignored for planning minima purposes. 'Tempo.', 'Inter.' and 'Gradu.' conditions are normally qualified by a time band and must be considered in determining the suitability of an aerodrome with respect to planning minima. Where a time band is omitted then the conditions

need not be considered with respect to planning minima. The commander is expected however to exercise good judgement in assessing the overall weather conditions when making a decision to exclude 'Tempo.', 'Inter.', 'Gradu.' and 'Prob.' conditions.

3 Planning Minima

- 3.1 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 weather minima for despatch purposes (Planning Minima) should be higher than the weather minima required to initiate a normal instrument approach. This is necessary to ensure that the instrument approach and landing can be conducted safely if the flight has to divert to the alternate aerodrome. Additionally, since the visual reference required to safely complete an approach and landing is determined, amongst other things, by the accuracy with which the aeroplane can be controlled along the approach path by reference to instruments, and by the accuracy of ground-based instrument aids, as well as by 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.
- 3.2 Pending the results of further research, the following standard en-route alternate planning weather minima are to be established for flight planning and despatch purposes with twin-engined aeroplanes in extended range operations. The Authority will consider any proposals which can be shown to be no less safe than this method. These weather minima recognise the benefits of ILS/MLS, as well as the increased assurance of safely completing an instrument approach at aerodromes which are equipped with ILS/MLS approaches to at least two separate runways. A particular aerodrome may be considered to be a **suitable** aerodrome for flight planning and despatch purposes for extended range operations if it meets the criteria of Chapter 4, paragraph 4.5, and has forecast weather (in accordance with Chapter 4) at or better than the following planning minima:
- a) **Single ILS/MLS, or PAR:**
Cloudbase of 600 feet and a visibility of 3 km (2 statute miles) or a cloudbase of 400 feet and a visibility of 1.5 km (1 statute mile) above the lowest authorised landing minima; whichever is higher.
 - b) **Non-precision and circling approaches (including SRA):**
Cloudbase of 800 feet and a visibility of 3 km (2 statute miles) or a cloudbase of 400 feet and a visibility of 1.5 km (1 statute mile) above the lowest authorised landing minima; whichever is higher.
 - c) **Two or more ILS/MLS/PAR to separate runways:**
Where forecast wind and surface conditions indicate that two or more separate runways will be available within the Rule Distance, whether at one or more airfields, the relevant Planning Minima cloudbase may be reduced by 200 feet and the visibility by 1 km (½ statute mile).
- 3.3 The appropriate planning minima may only be used if the expected wind and surface conditions would permit an engine-out landing on the runway(s) served by the aid(s). For planning purposes the expected cross-winds, including gusts, 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 that aerodrome, should not exceed

the maximum permitted cross-wind for landing, taking into account the factors of Chapter 4, paragraph 4.5 a), unless otherwise agreed with the Authority. In all cases, the Authority may direct that higher planning minima shall apply. However, the Authority may approve lower aerodrome planning minima for a specific en-route alternate aerodrome on the basis of favourable special meteorological, terrain and operational studies produced by an operator or group of operators.

- 3.4 At suitably equipped aerodromes, lower than standard en-route alternate planning weather minima may be considered for approval for certain operators on a case-by-case basis by the Authority, for those aeroplanes which have the certificated capability to safely conduct Category 2 and/or 3 approach and landing operations after encountering any failure condition(s) in the airframe and/or propulsion systems which would result in a diversion. The certificated capability of the aeroplane will be evaluated considering the approved maximum diversion time, and subsequent failures during the diversion affecting Cat 2/3 capability should be shown to be improbable. Such lower than standard en-route alternate planning weather minima will not be lower than the published Cat 1 weather minima.
- 3.5 Once an ETOPS aeroplane has been despatched, the suitability of an en-route alternate aerodrome for an aeroplane which encounters a situation which necessitates a diversion, while en-route on an extended range operation, is based on a determination that the aerodrome is still suitable (as used in ANO Article 28(1)(c)) for the circumstances, and that the weather conditions at that aerodrome will permit an instrument approach to be initiated and landing completed. In the event that the weather deteriorates at a specified alternate, so that it is unlikely that a successful landing could be achieved, the Commander should re-plan the flight to come within the specified Rule Distance of another more suitable alternate.

Appendix C ETOPS Maintenance Requirements

1 General

The maintenance programme should contain the standards, guidance, and direction necessary to support the intended operations. Maintenance personnel involved 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

The basic maintenance programme for the aircraft being considered for ETOPS is the continuous airworthiness maintenance schedule currently approved for that operator, for the make and model airframe/engine combination. This schedule should be reviewed to ensure that it provides an adequate basis for development of ETOPS maintenance requirements. These should include maintenance procedures to preclude identical action being applied to multiple similar elements in any ETOPS critical system (e.g. fuel control change on both engines).

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

3 ETOPS Manual

The operator should develop a manual for use by personnel involved in ETOPS. This manual need not include, but should at least reference, the maintenance programme and other requirements described by this Appendix, and clearly indicate where they are located in the operator's manual system. All ETOPS requirements, including supportive programme procedures, duties and responsibilities, should be identified and be subject to revision control. This manual should be submitted to the Authority 30 days before implementation of ETOPS flights. Alternatively the operator may include this information in existing manuals used by personnel involved in ETOPS.

4 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 oil analysis is meaningful to this make and

model, it should be included in the programme. If the APU is required for ETOPS operation, it should be added to the oil consumption programme.

5 Engine Condition Monitoring

This programme should describe the parameters to be monitored, method of data collection and corrective action process. The programme should reflect manufacturers' 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.

6 Rectification of Aircraft Defects

The operator should develop a verification programme, or procedures should be established, to ensure corrective action following an engine shutdown, primary system failure, adverse trends or any prescribed events which require verification flight or other action and establish means to assure their accomplishment. 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. Primary systems or conditions requiring verification actions should be described in the operator's ETOPS manual.

7 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 Authority to help establish that the reliability level is adequate, and to assess the operator's competence and capability to safely continue ETOPS. The Authority should be notified within 96 hours of events reportable through this programme.

- a) In addition to the items addressed by CAP 418 (Condition Monitored Maintenance) for routine reliability reporting, the following items should be included:
 - i) In-flight shutdowns.
 - ii) Diversion or turnback.
 - iii) Uncommanded power changes or surges.
 - iv) Inability to control the engine or obtain desired power.
 - v) Problems with systems critical to ETOPS.
 - vi) Any other event detrimental to ETOPS.
- b) The report should identify the following:

- i) Aircraft identification.
- ii) Engine identification (make and serial number).
- iii) Total time, cycles, and time since last shop visit.
- iv) For systems, time since overhaul or last inspection of the defective unit.
- v) Phase of flight.
- vi) Corrective action.

8 Propulsion System Monitoring

The operator's assessment of propulsion systems reliability for the extended range fleet should be made available to the Authority (with the supporting data) on at least a monthly basis, to ensure that the approved maintenance programme continues to maintain a level of reliability necessary for extended range operations. Any adverse trend would require an immediate evaluation to be accomplished by the operator in consultation with the Authority. The evaluation may result in corrective action or operational restriction being applied.

9 Maintenance Training

Maintenance training should focus on the special nature of ETOPS. This programme should be included in normal maintenance training. The goal of this programme is to ensure that all personnel involved in ETOPS are provided the necessary training so that the ETOPS maintenance tasks are properly accomplished and to emphasise the special nature of ETOPS maintenance requirements. Qualified maintenance personnel are those that have completed the operator's extended range training programme and have satisfactorily performed extended range tasks under supervision, within the framework of the operator's approved procedures for Personnel Authorisation.

10 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 aircraft during parts borrowing or pooling arrangements as well as those parts used after repair or overhaul, maintain the necessary ETOPS configuration for that aircraft.

Addendum Reduction of Operators' In-Service Experience Prior to the Granting of an ETOPS Approval

NOTE: This addendum is published now so that operators might have immediate guidance on the required contents of an application for an ETOPS Approval without the normal one year in-service experience and the limitations which this Authority may place on such an Approval. The Joint Aviation Authority (JAA) is planning to publish advisory material on the same subject towards the end of 1995 which will be harmonised with Federal Aviation Administration (FAA) requirements but may be different in some respects from the information published here. This addendum should therefore be considered an interim position which will be reviewed and amended in the light of the experience gained up to that date, in conjunction with the JAA/FAA harmonised advisory material.

1 Introduction

The assessment of an operator's suitability to be granted an ETOPS Approval is routinely made after a 12 month period of operating the nominated airframe/engine combination on non-ETOPS routes. However, in some cases it may not be feasible, because of the nature of the operation, for an operator to complete this 12 month period on non-ETOPS routes and the purpose of this addendum is to give guidance to an operator as to how an ETOPS Operational Approval with reduced in-service experience may be obtained.

The facility to obtain Operational Approval with reduced in-service experience does not imply that any reduction of existing standards will be tolerated but rather acknowledges the possibility that an operator may be able to satisfy the existing standards specified in CAP 513 by demonstrating an equivalent capability in less than 12 months of operation. The content of this addendum is applicable only to consideration of granting an Operational Approval for operating an airframe/engine combination which has been awarded Type Design Approval (TDA) for ETOPS. The issue of reduced in-service experience of an airframe/engine combination prior to the award of ETOPS TDA is a matter for the manufacturer and the certifying Authority and is beyond the scope of this document.

CAP 513 will remain the standard against which an applicant for ETOPS Operational Approval will be assessed and so the objectives of this addendum are to identify elements of such an Approval and state an alternative means of compliance with the associated requirements.

The standards required for a 120 minute rule time ETOPS Approval are the minimum acceptable for any Operational Approval, even though such an Operational Approval might be restricted to some reduced rule time (75 minutes or 90 minutes) during the initial period of operations.

The standards required for a 120 minute rule time ETOPS Operational Approval are the equivalent of those stated in Chapter 4 and Appendix C of CAP 513.

2 Requirements

The operator should normally submit an 'Accelerated ETOPS Operational Approval Plan' to the Authority six months, but never later than three months, before the proposed start of operations. This six-month period will give an opportunity for the operator to incorporate any refinements that may be required by the Authority to achieve an Accelerated Approval. The plan which is additional to the normally required ETOPS submission will fully define his proposals and include details of proposed routes, the ETOPS rule time necessary to support these routes and the factors which are being claimed as compensation for the normally required in-service experience.

Factors which may be considered as justification for an accelerated ETOPS Approval include:

- a) The demonstrated commitment, by the management of the operating company, to the standards and practices of ETOPS.
- b) The operator's maintenance and operational experience
 - i) as a previous ETOPS operator
 - ii) as a previous long range operator
 - iii) with similar technology aeroplanes
 - iv) with similar technology engines
- c) The support to be given by airframe, engine and APU manufacturers after commencement of operations.
- d) Maintenance or operational support from established ETOPS operators, or ETOPS maintenance organisations.
- e) The experience gained by flight crews, maintenance personnel and despatch staff whilst working with other ETOPS Approved operators.

The factors mentioned above can be supported by the operator establishing the following procedures, as appropriate:

- A Early instigation of ETOPS procedures on other aeroplane fleets.
- B A programme to retain 'key personnel' in situ after commencement of operations.
- C Carriage of additional contingency fuel which will increase the holding fuel mentioned in connection with the critical fuel scenario to a minimum of 30 minutes.
- D Fully documented procedures for the management of sub-contracted maintenance.

3 Operational Approval Considerations

When considering an application for an accelerated ETOPS Operational Approval the Authority must be satisfied that the standards established by the operator are equivalent to those operating standards which would normally be expected after 12 months in-service experience.

Particular attention will be paid to:

- a) The operator's overall safety record
- b) Past performance
- c) Flight crew training
- d) Maintenance training
- e) Maintenance programmes
- f) Control procedures when maintenance support is provided by some other organisation.
- g) Control and checking procedures when flight despatch (inc computerised flight planning, meteorological information, loading data) is provided by some other organisation.

4 Operator's Propulsion System Reliability

The propulsion system will have demonstrated over the world-wide fleet an established IFSD consistent with the Operational Approval sought. The operator will demonstrate, to the satisfaction of the Authority, that there has been established a preventative maintenance and health monitoring programme for the engines that will maintain this level of propulsion system reliability.

5 Engineering Modification and Maintenance Programme Considerations

The requirements of CAP 513 Chapter 4, paragraph 3 must be satisfied and

- a) Maintenance and training procedures practices and limitations established for extended range operations must be considered suitable and will have remained unchanged for an appropriate period.
- b) A Reliability Reporting procedure will be in place and will have been demonstrated to the satisfaction of the Authority.
- c) The operator will demonstrate an established procedure for prompt implementation of modifications and inspections which could affect propulsion system and airframe system reliability.
- d) The Authority must be satisfied that a procedure has been established and demonstrated which fulfills the requirements of Chapter 4, paragraph 3.6, Maintenance Programme.
- e) The engine condition monitoring programme specified at Chapter 4, paragraph 3.7 must be demonstrated to be established and functioning.
- f) The oil consumption monitoring programme must be demonstrated to be established and functioning.

6 Flight Despatch Considerations

The operator must demonstrate to the satisfaction of the Authority that despatch procedures are in place and satisfactory for the operation being conducted. An operator with no previous ETOPS experience may obtain support from an established ETOPS operator to facilitate ETOPS despatch, but this does not in any way absolve them from the responsibilities for control and checking of such procedures. Flight deck crews must demonstrate their ability to cope with pre-departure and en-route

changes to planned route, en-route monitoring and diversion procedures. Both flight despatch staff and flight crews must demonstrate familiarity with the routes to be flown, in particular the requirements for and selection of en-route alternates. During the initial period of operation the operator may be required to operate in accordance with a restricted MEL and with increased contingency fuel.

7 Flight Crew Training and Evaluation Programme

The operator must demonstrate a training and evaluation programme that fulfills all the requirements specified in Chapter 4, paragraph 5. The Authority must be satisfied that the crew members nominated as ETOPS qualified by the operator are properly trained and capable of dealing with any situation which might be encountered during extended range operations. If considered appropriate the Authority may require flight crew members to undertake additional flight simulator training to compensate for limited in-service experience on the aeroplane type.

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

8 Operational Limitations

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

Operators who successfully demonstrate a capability consistent with the standards required for an Operational Approval with a rule time of 120 minutes may be required to progress to this level of approval by the steps specified below.

- a) Operators who have previous ETOPS experience with similar technology aeroplanes and similar technology engines can apply for a 120 minute rule time Operational Approval at Entry into Service (EIS) of the new type.
- b) Operators who have previous long range experience and experience with similar technology aeroplanes and similar technology engines can apply for a 90 minutes Approval at EIS and must satisfactorily complete a three month period and a minimum of 100 sectors before progressing to a 120 minute Approval.
- c) Operators who have no previous long range experience but obtain appropriate maintenance and operational support from an established ETOPS Approved organisation can apply for a 90 minute Approval and must satisfactorily complete a three month period and a minimum of 100 sectors before progressing to a 120 minute Approval.
- d) Operators who intend to commence ETOPS operations with personnel who have gained appropriate experience with other ETOPS Approved operators can apply for a 75 minute Approval and must satisfactorily complete a three month period and 100 sectors before progressing to a 90 minute Approval and they must satisfactorily complete a further three month period and 100 sectors before progressing to a 120 minute Approval.

- e) Assessment of an operator's suitability to increase the rule time past 120 minutes will be based on the criteria described at Chapter 4, paragraph 6.2 b)

9 Operations Manual

In addition to the requirements specified at Chapter 4, paragraph 7, the operations manual must include a section explaining the special nature of the accelerated ETOPS Operational Approval and emphasize the limitations of the process, i.e. restricted rule times 75/90 minutes, and restricted ETOPS MEL if applicable. Any conservative operational procedures which have gained credit, i.e. increased contingencies, should be explained in detail.

10 Quality Assurance

An accelerated programme leading to an Operational Approval is considered feasible so long as the operator retains commitment to the standards which are contained in the Accelerated ETOPS Operational Approval Plan and associated programmes. Therefore the operator must put in place a comprehensive self-audit quality assurance system which will monitor all aspects of the operation.

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