Federal Aviation Administration
Aviation Rulemaking Advisory Committee

Air Carrier Operations Issue Area
Extended Range Operations of Airplanes (ETOPS) Working Group

Task 1 –Extended Range Operations with two-Engine Aircraft

Task Assignment

[Federal Register: June 14, 2000 (Volume 65, Number 115)]
[Notices]
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DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

Aviation Rulemaking Advisory Committee; Air Carrier Operations Issues--New Task

AGENCY: Federal Aviation Administration (**FAA**), DOT.

ACTION: Notice of new task assignment for the Aviation Rulemaking Advisory Committee (ARAC).

SUMMARY: Notice is given of a new task assigned to and accepted by the Aviation Rulemaking Advisory Committee (ARAC). This notice informs the public of the activities of ARAC.

FOR FURTHER INFORMATION CONTACT: Eric Van Opstal, Federal Aviation Administration (AFS-200), 800 Independence Avenue, SW., Washington, DC 20591; phone (202) 267-3774; fax (202) 267-5229.

SUPPLEMENTARY INFORMATION:

Background

The **FAA** has established an Aviation Rulemaking Advisory Committee to provide advice and recommendations to the **FAA** Administrator, through the Associated Administrator for Regulation and Certification, on the full range of the **FAA**'s rulemaking activities with respect to aviation-related issues. One area ARAC deals with is air carrier operations issues. These issues involve the operational requirements for air carriers, including crewmember requirements, airplane operating performance and limitations, and equipment requirements.

The Task

This notice informs the public that the **FAA** has asked ARAC to provide advice and recommendation on the following task:

Extended Range Operations with Two-Engine Aircraft (ETOPS)

1. Review the existing policy and requirements found in Advisory Circular (AC) 120-42A, applicable ETOPS special conditions, and policy memorandums and notices, for

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certification and operational regulations and guidance material for ETOPS approvals up to 180 minutes.

2. Develop comprehensive ETOPS airworthiness standards for 14 CFR parts 25, 33, 121, and 135, as appropriate, to codify the existing policies and practices.

3. Develop ETOPS requirements for operations and excess of 180 minutes up to whatever extent that may be justified. Develop those requirements such that incremental approvals up to a maximum may be approved.

4. Develop standardized requirements for extended range operations for all airplanes, regardless of the number of engines, including all turbojet and turbopropeller commercial twin-engine airplanes (business jets), excluding reciprocating engine powered commercial airplanes. This effort should establish criteria for diversion times up to 180 minutes that is consistent with existing ETOPS policy and procedures. It should also develop criteria for diversion times beyond 180 minutes that is consistent with the ETOPS criteria developed by the working group.

5. Develop additional guidance and/or advisory material as the ARAC finds appropriate.

6. Harmonize such standardized requirements across national boundaries and regulatory bodies.

7. Any proposal to increase the safety requirements for existing ETOPS approvals up to 207 minutes must contain data defining the unsafe conditions that would warrant the safety requirements.

8. The working group will provide briefings to the Transport Airplane and Engine Issues group.

9. The recommendations should consider the comments received as a result of the April 27, 1999 and January 21, 2000 Federal Register notices.

10. Within one year of publication of the ARAC task in the Federal Register, submit recommendations to the **FAA** in the form of a proposed rule.

Working Group Activity

The ETOPS Working Group is expected to comply with the procedures adopted by ARAC. As part of the procedures, the working group is expected to:

1. Recommend a work plan for completion of the tasks, including the rationale supporting such a plan, for consideration at the meeting of ARAC to consider air carrier operations issues held following publication of this notice.

2. Give a detailed conceptual presentation of the proposed recommendations, prior to a proceeding with the work stated in item 3 below.

3. Draft an appropriate report.

4. Provide a status report at each meeting of ARAC held to consider air carrier operations issues.

Participation in the Working Group

The ETOPS Working Group is composed of experts having an interest in the assigned task. A working group member need not be a representative of a member of the full committee.

A person who has expertise in the subject matter and wishes to become a member of the working group should contact Mark Lawyer, Federal Aviation Administration (ARM-107), 800 Independence Avenue, SW., Washington, DC 20591; phone (202) 493-4531; fax (202) 267-5075; email mark_lawyer@**faa**.gov. The person should describe his or her interest in the tasks and state the expertise he or she would bring to the working group. The request will be reviewed by the assistant chair, the assistant executive director, and the working group chair. The person will be advised whether or not the request can be accommodated. Requests to participate on the ETOPS Working Group should be submitted no later than June 26, 2000. To the extent possible, the composition of the working group will be balanced among the aviation interests selected to participate.

The Secretary of Transportation has determined that the formation and use of ARAC are necessary and in the public interest in connection with the performance of duties imposed on the **FAA** by law.

Meetings of ARAC will be open to the public. Meetings of the ETOPS Working Group will not be open to the public, except to the extent that individuals with an interest and expertise are selected to participate. No public announcement of working group meetings will be made.

Issued in Washington, DC, on June 7, 2000.
Gregory L. Michael,
Assistant Executive Director for Air Carrier Operations Issues,
Aviation Rulemaking Advisory Committee.
[FR Doc. 00-14911 Filed 6-13-00; 8:45 am]
BILLING CODE 4910-13-M

Recommendation Letter

Timothy N. Gallagher
1804 Reynolds Court
Crofton, MD 21114

October 28, 2002

Mr. Bill Edmunds
Chairman
ARAC Air Carrier Operations Issues Group
Air Line Pilots Association
535 Herndon Parkway
Herndon, VA 20172-1169

Dear Mr. Edmunds:

On July 30, 2002, I forwarded to you the report of the ARAC ETOPS Working Group. That report, in response to the ARAC Tasking Statement, included a recommended Notice of Proposed Rulemaking and associated Advisory Circulars for Parts 1, 21, 25, 33 and 121 of the Federal Aviation Regulations. The material for Part 135 was promised as an addendum when complete.

Today, I am pleased to forward the last remaining portion of the ETOPS WG recommendation for proposed rules and advisory material for Part 135. Enclosed is a complete document with all proposed rules and AC's. For purposes of review by the Air Carrier Operations Issues Group, please be advised that the attached document is unchanged from the document I forwarded to you on July 30, 2002, with respect to Parts 1, 21, 25, 33 and 121. The new material includes a preamble section specific to Part 135, Part 135 proposed rules, an AC on Part 135 Polar Operations and an AC on Part 135 ETOPS. There are also minor changes to the general portion of the preamble.

As I commented in my previous letter, the members of the ETOPS Working Group, and their sponsors, are to be commended for their dedication to the assigned task. That dedication continued in evidence as the group completed the Part 135 portion. A special note of gratitude is due the working group representatives of the Part 135 community for their team spirit and willingness to form a consensus proposal.

I will be pleased to assist the Air Carrier Operations Issues Group in any way I can during their review of our report.

Sincerely,

Timothy N. Gallagher
Chair, ARAC ETOPS WG

Enclosure

Home Phone 410-721-3698 Cell Phone 303-517-7788 Email TimGallagher@att.net

Action: ARM
cc AFS

AIR LINE PILOTS ASSOCIATION, INTERNATIONAL

535 HERNDON PARKWAY □ P.O. BOX 1169 □ HERNDON, VIRGINIA 20172-1169 □ 703-689-2270
FAX 703-689-4370

December 17, 2002

Mr. Nicholas Sabatini, AVR-1
Federal Aviation Administration
800 Independence Avenue, SW
Washington, DC 20591

Dear Mr. Sabatini:

The Air Carrier Operations Issues Group of the Aviation Rulemaking Advisory Committee met on December 16, 2002 to consider the report and recommendations of the Extended Range Operations with Two-Engine Aircraft (ETOPS) Working Group. Their recommendation includes a draft notice of proposed rulemaking (NPRM) and a supporting draft advisory circular.

The working group did an excellent and thorough job of meeting the tasks assigned to them. They worked very diligently to assure that their product represents a high degree of consensus on the issues they considered. Their recommended NPRM is intended to preclude aircraft diversions and protect any aircraft that may be subject to a diversion. It will introduce a higher level of safety in all extended range operations, not just those flown with two-engine aircraft.

The support of FAA personnel to the working group was exemplary and a strong determinant of the overall success of the working group.

The issues group noted that these working group recommendations represent a definite enhancement of aviation safety in international operations. International regulators participated in the working group deliberations and we understand that these regulators are considering safety provisions in extended range operations in their own regulations. We urge the FAA to assist these regulators in their efforts to assure the highest levels of harmonization.

The Air Carrier Operations Issues Group is pleased to forward the working group recommendations to you for further action. not enclosed?

Sincerely yours,

W W Edmunds Jr

William W. Edmunds, Jr., Chairman
Air Carrier Operations Issues Group

Acknowledgement Letter

Mr. Williams W. Edmunds, Jr.
Air Line Pilots Association January 28, 2003
P.O. Box 1169
Herndon, VA 20170

Dear Mr. Edmunds:

We have received your December 17 letter announcing the completion of the work of the Extended Range Operations with Two-Engine Aircraft (ETOPS) Working Group. Their recommendation, which has been posted on the Office of Rulemaking website, contains a draft notice of proposed rulemaking and a supporting advisory circular.

I agree that the working group did an excellent and thorough job in meeting the tasks assigned them. The minutes of the December 16 Air Carrier Operations Issues group meeting reflect the wide range of consensus that was achieved throughout industry and with certain public interests in developing these recommendations.

The next task is within the FAA – to gain priority for the project so that resources may be dedicated to publishing an NPRM. I understand that my staff is working diligently toward achieving that task.

I appreciate the dedication of the working group to the tasks assigned and the leadership of Tim Gallagher, who persevered in completing the tasks.

I also appreciate your continued excellent leadership of the issues group in support of the Aviation Rulemaking Advisory Committee.

Sincerely,

/s/ Nick Sabatini

Nicholas A. Sabatini
Associate Administrator for
Regulation and Certification

Recommendation

Contents: (This page of links is to be used as a search tool by ARAC members during their review of the document. It is not comprehensive nor is it intended to be part of the NPRM.)

DEPARTMENT OF TRANSPORTATION
Federal Aviation Administration
14 CFR Parts [1, 21, 25, 33, 121, 135].
[Docket No. FAA-2002- ; Notice No.]

RIN

Title: Extended Operations (ETOPS) of Multi-engine Airplanes
AGENCY: Federal Aviation Administration (FAA), DOT.
ACTION: Notice of proposed rulemaking (NPRM).
SUMMARY: Since 1985, specified U. S. certificated air carriers have been authorized by the Administrator, through a deviation from 14CFR121.161, to operate two-engine airplanes over routes with points more than one hour from an adequate airport. These authorizations have been guided by Advisory Circular 120-42, as amended, and various FAA policy letters, and granted through the provisions of FAA Operations Specifications. These extended range operations have been known as ETOPS and have proven to be successful both in terms of safety and efficiency, chiefly because they have been carefully specified and closely monitored by the manufacturers, the air carriers, professional pilot associations and the FAA. Moreover, other extended range operations have been conducted safely for decades by air carrier airplanes with more than two engines and by other commercial operators under 14CFR135.

Many lessons have been learned during decades of extended range operations in general, and specifically since the inception of ETOPS in 1985. These lessons extend not only to the manufacture, equipage and operation of airplanes, but also to the safeguarding of passengers and crewmembers especially during en route diversions. The FAA has determined that it is now time to promulgate regulations and updated advisory material to govern not only extended range air carrier operations of two-engine airplanes, but also all extended range operations where ETOPS lessons learned indicate that such regulations and guidance are appropriate.

The regulations proposed in this notice would codify the ETOPS provisions that have been embodied in AC 120-42, as amended, and various other FAA policy documents that have been issued from time to time since 1985. The proposed regulations would also extend to other operations, as appropriate, to safeguard extended range operations that are not linked to the specific number of an airplane's engines. Finally, revised or new guidance material, an addendum to this notice, would provide information and guidance to those concerned with the manufacture or operation of airplanes used in extended range operations and facilitate their compliance with pertinent regulations.

DATES: Send your comments on or before [*Insert date 30/45/60/90/120 days after date of publication in the Federal Register.*]

ADDRESSES: Address your comments to the Docket Management System, U.S. Department of Transportation, Room Plaza 401, 400 Seventh Street, SW., Washington, DC 20590-0001. You must identify the docket number FAA-2002-XXXXX at the beginning of your comments, and you should submit two copies of your comments. If you wish to receive confirmation that FAA received your comments, include a self-addressed, stamped postcard.

You may also submit comments through the Internet to http://dms.dot.gov . You may review the public docket containing comments to these proposed regulations in person in the Dockets Office between 9:00 a.m. and 5:00 p.m., Monday through Friday, except Federal holidays. The Dockets Office is on the plaza level of the NASSIF Building at the Department of Transportation at the above address. Also, you may review public dockets on the Internet at http://dms.dot.gov.

FOR FURTHER INFORMATION CONTACT: [Name] *(Person most knowledgeable about the technical contents of the document,* d*o not use a title; i.e., Mr., Ms.),* [Branch/Division], [Routing Symbol], Federal Aviation Administration, 800 Independence Avenue SW., Washington, DC 20591; telephone (202) 267-XXXX; facsimile (202) 267-XXXX.

SUPPLEMENTARY INFORMATION:

Comments Invited The proposed action in this notice was developed by an ETOPS working group (WG) of the Air Carrier Operations Issues Group of the FAA's Aviation Rulemaking Advisory Committee (ARAC), a committee chartered under the Federal Advisory Committee Act (FACA). ETOPS WG members volunteered for membership and were selected on the basis of interest and expertise, as provided for in the ARAC procedures. WG members represented all aspects of extended range airplane operations from aircraft and engine manufacturers to air carriers and commercial operators to professional pilot associations to airline passenger advocates. The proposal enjoys broad consensus among WG members, a chief objective of the ARAC process. Nevertheless, interested persons are invited to participate in the making of the proposed action by submitting such written data, views, or arguments as they may desire. Comments relating to the environmental, energy, federalism, or economic impact that might result from adopting the proposals in this document also are invited. Substantive comments should be accompanied by cost estimates. Comments must identify the regulatory docket or notice number and be submitted in duplicate to the DOT Rules Docket address specified above.

All comments received, as well as a report summarizing each substantive public contact with FAA personnel concerning this proposed rulemaking, will be filed in the docket. The docket is available for public inspection before and after the comment closing date.

All comments received on or before the closing date will be considered by the Administrator before taking action on this proposed rulemaking. Comments filed late will be considered as far as possible without incurring expense or delay. The proposals in this document may be changed in light of the comments received.

Commenters wishing the FAA to acknowledge receipt of their comments submitted in response to this document must include a pre-addressed, stamped postcard with those comments on which the following statement is made: "Comments to Docket No. FAA-2002-XXXX." The postcard will be date stamped and mailed to the commenter.

Availability of Rulemaking Documents

You can get an electronic copy using the Internet by taking the following steps:

(1) Go to the search function of the Department of Transportation's electronic Docket Management System (DMS) web page (http://dms.dot.gov/search).

(2) On the search page type in the last four digits of the Docket number shown at the beginning of this notice. Click on "search."

(3) On the next page, which contains the Docket summary information for the Docket you selected, click on the document number of the item you wish to view.

You can also get an electronic copy using the Internet through FAA's web page at http://www.faa.gov/avr/arm/nprm/nprm.htm or the Federal Register's web page at http://www.access.gpo.gov/su_docs/aces/aces140.html.

You can also get a copy by submitting a request to the Federal Aviation Administration, Office of Rulemaking, ARM-1, 800 Independence Avenue SW., Washington, DC 20591, or by calling (202) 267-9680. Make sure to identify the docket number, notice number, or amendment number of this rulemaking.

Background

Statement of the Problem Since 1985, extended range operations (ETOPS) of air carrier two-engine airplanes have been authorized by deviation from 14CFR121.161. Deviation authority is provided in certain regulations to allow for unforeseen or unusual circumstances where those being regulated may be able to justify an action different from that required by the regulation. Deviation authority is not intended for widespread or long-term use as a substitute for rulemaking. ETOPS have now become so extensive and mature that they should no longer be permitted by rule deviation, but by specific regulations as proposed in this notice. Furthermore, other extended operations by air carriers with airplanes having more than two engines and by commercial operators with various airplane types, while having been conducted successfully, have nonetheless been without minimum regulatory requirements in certain areas where two engine ETOPS experience shows such requirements now should be specified.

History

ARAC ETOPS WG Task Statement

The ARAC ETOPS WG was established through a notice at 65FR37447, dated June 14, 2000. It was given the following tasks:

1. Review the existing policy and requirements found in Advisory Circular (AC) 120-42A, applicable ETOPS special conditions, and policy memorandums and notices, for certification and operational regulations and guidance material for ETOPS approvals up to 180 minutes.
2. Develop comprehensive ETOPS airworthiness standards for 14 CFR parts 25, 33,121, and 135, as appropriate, to codify the existing policies and practices.
3. Develop ETOPS requirements for operations in excess of 180 minutes up to whatever extent that may be justified. Develop those requirements such that incremental approvals up to a maximum may be approved.
4. Develop standardized requirements for extended range operations for all airplanes, regardless of the number of engines, including all turbojet and

turbopropeller commercial twin-engine airplanes (business jets), excluding reciprocating engine powered commercial airplanes. This effort should establish criteria for diversion times up to 180 minutes that is consistent with existing ETOPS policy and procedures. It should also develop criteria for diversion times beyond 180 minutes that is consistent with the ETOPS criteria developed by the working group.

5. Develop additional guidance and/or advisory material as the ARAC finds appropriate.
6. Harmonize such standardized requirements across national boundaries and regulatory bodies.
7. Any proposal to increase the safety requirements for existing ETOPS approvals up to 207 minutes must contain data defining the unsafe conditions that would warrant the safety requirements.
8. The working group will provide briefings to the Transport Airplane and Engine Issues group.
9. The recommendations should consider the comments received as a result of the April 27, 1999 and January 21, 2000 **Federal Register** notices.
10. Within one year of publication of the ARAC task in the **Federal Register**, submit recommendations to the FAA in the form of a proposed rule.

ARAC ETOPS WG Infrastructure and Work Plan

The ARAC ETOPS WG was not provided with any infrastructure, nor did it have any budget. The FAA made available a restricted website for posting of documents, as well as a FAA liaison and advisors.

To accomplish the above list of tasks, the WG developed a work plan that called for twelve meetings over the one year period allowed by the tasking. The meetings were held approximately once a month and lasted 3-4 days each. The meetings were held at various locations and were hosted by the constituents of the WG members. These variable meeting sites were in accordance with established ARAC guidelines and allowed members to witness first hand manufacturing sites, airline operations, pilot association offices and other venues, all of which gave a sense to members of the expertise brought to the task and to aviation safety. Variable meeting sites also spread the travel burden of this self-financed working group made up of both U.S. and foreign representatives. Two joint meetings were held with the JAA in Munich, Germany and in Toulouse, France. One briefing meeting for the International Civil Aviation Organization was held in Montreal, Canada. Two meetings took place at the FAA Center for Management Development in Palm Coast, Florida and one meeting was held at FAA Headquarters in Washington, DC.

At the conclusion of the originally-planned twelve meetings, the WG had not been able to conclude their work, but they had met sufficiently to air all relevant issues, gain consensus and move to a drafting phase with a time extension granted by the FAA. The drafting phase was delayed for various reasons, among them the changes in the economic conditions of some of the WG members' constituents resulting in the departure of some active and valuable participants, as well as by the tragic events of September 11, 2001. Nonetheless, the drafting phase was concluded in time for a final meeting of the WG in May 2002.

Without any infrastructure, no minutes were kept of the WG proceedings. Instead it was decided to express diverse views in the preamble to the proposed rules and advisory materials which should give the FAA a good background understanding.

It was further decided to adopt the principle what the members and their constituents can "live with" in order to achieve consensus, instead of divisive votes and minority reports.

It is estimated that the workgroup spent about twenty thousand work hours over the two year period of its deliberations at a cost of several million dollars.

Considering that valuable WG members were lost because of constituents' economic conditions, serious thought should be given if future ARAC should not be adequately funded and provided with a suitable infrastructure to secure the talents and experts which are needed to conduct successfully such advisory operations with the needed expertise.

ARAC ETOPS WG Concept for Regulatory Requirements and Guidance Material
In accordance with the task statement and the WG's work plan approved by the ARAC Air Carrier Operations Issues Group on August 15, 2000, the WG reviewed existing ETOPS documents and developed a risk assessment method for ETOPS and other long range flights. The risk assessment method is comprised of three parts: a loss of thrust model; a system safety analysis using the FAR/JAR 25.1309 process; and an operational assessment assuring that pertinent operational considerations are taken into account. Underlying the WG's proposals for new regulations and advisory material are the following general concepts:

- Special considerations for extended range flights are designed to prevent the need for a diversion and to protect the diversion when it cannot be prevented
- Airplanes must be designed and built for the intended mission
- Airplanes so designed and built must be maintained at a level that preserves the original reliability
- At some level of engine reliability, as measured by the In Flight Shut Down (IFSD) rate (.01 per 1000 engine flight hours for twins), the risk of independent failures leading to loss of all thrust ceases to limit the operation, and other limiting factors come into play
- ETOPS should be defined in the future as flights more than 60 minutes from an adequate airport for two-engine air carrier airplanes, and more than 180 minutes from an adequate airport for air carrier airplanes with more than two engines and for all commercial operator jet-powered airplanes operated under 14 CFR 135.
- Certain ETOPS requirements should be applied to Polar operations even if those operations would otherwise not qualify as ETOPS
- Part 135 operations have unique considerations

As WG discussions continued, an additional concept was developed regarding the starting point for diversion time limits beyond those heretofore applied to ETOPS and for airplanes and operations that previously had not been restricted by ETOPS requirements. Acknowledging that any starting point for new diversion time limits would be somewhat subjective, the WG suggests that its members collectively have the requisite expertise and operational judgment to determine such new limits.

While the reliability of aircraft engines and systems have improved to the point that they may not be limiting to the operation, the WG believes that it is operationally prudent to remain within 180 minutes of an airport in air carrier two-engine airplanes in case a diversion is necessary for any reason, including reasons that do not have anything to do with aircraft reliability, such as passenger illness or other occurrences. It also acknowledges that there are occasional instances where that is not possible, and that given compliance with specific ETOPS requirements, it may be permissible, where needed, to be more than 180 minutes from an airport.

Regarding extended range operations by jet-powered airplanes under 14 CFR 135, FAA policy for many years has permitted such flights up to 180 minutes from an airport without additional ETOPS-like requirements. Operational experience has validated that policy, and the WG proposal continues existing policy and provides for flights with longer diversion times with appropriate additional requirements.

Regarding extended range operations by air carrier airplanes with more than two engines, those flights have been conducted without any ETOPS-like requirements since the air carrier jet era began. The WG proposal adds requirements that would ensure the continued safety of those flights in functional areas that are not dependent upon the number of engines on the airplane, such as cargo fire protection duration.

Accordingly, the ETOPS Working Group has proposed regulations and guidance material in three specific areas: Type Design (Parts 25 and 33); Part 121 Operations; and Part 135 Operations.

<u>NTSB Recommendations</u> Regulatory proposals often result from NTSB recommendations. It is significant that in the area of ETOPS, there are no relevant NTSB recommendations.

<u>Reference Material</u> The primary ETOPS reference document is Advisory Circular 120-42A. Specific airline approvals for ETOPS are contained in pertinent FAA Operations Specifications. Two **Federal Register** publications contain notices related to ETOPS: 64FR22667, dated April 27, 1999, titled “207-minute Extended Range Operations with Two-engine Aircraft (ETOPS) and 65FR3520, dated January 21, 2000, with the same title. The first contained the Air Transport Association’s petition for 207-minute ETOPS and the second contained the FAA response granting approval of 207-minute ETOPS under very limited conditions, and announcing FAA’s intention to establish the instant ARAC ETOPS WG. An FAA policy letter “Guidance for Polar Operations,” dated February 28, 2001, is also available.

<u>Related Activity</u> Two related activities should be noted. First, the Joint Aviation Authorities (JAA) of European nations have chartered an ETOPS work group that is developing standards and guidance material concurrently with the U. S. effort. In ongoing efforts of both the FAA and JAA to coordinate regulatory requirements, one of the ARAC ETOPS WG tasks was to "harmonize …standardized requirements across national boundaries and regulatory bodies." Toward that end, there are representatives who are members of both the ARAC ETOPS WG and the JAA ETOPS WG. Also, the two groups met together twice in Europe to facilitate joint action and harmonization. Second, the International Civil Aviation Organization (ICAO) Air Navigation Commission (ANC) Operations Panel has taken a task to develop standards and recommended practices (SARPS) for extended range operations. The ARAC ETOPS WG held one of its meetings in Montreal, Quebec, Canada (ICAO headquarters city) for the purpose of briefing members of the ANC and ICAO Air Navigation Bureau staff.

<u>Current Requirements</u> *If appropriate, current requirements.*

General Discussion of the Proposals
In any consideration of safety regulations, terminology is a critical factor. In the section-by-section discussion following this general discussion, a number of terms are defined. The WG's deliberation on the terminology to be applied to the operations under consideration in this regulatory proposal deserves mention here.

Until now, the term ETOPS has been used to describe extended range operations for two-engine airplanes; that is, for operations allowed by deviation from 14 CFR 121.161. The term has developed broad acceptance and respect throughout industry and regulatory bodies. The additional regulatory requirements that must be met for ETOPS have proven to be wisely chosen and carefully followed, resulting in notable accomplishments in safety and efficiency. Members of the aviation community who apply and oversee these additional ETOPS requirements have developed a commitment to ETOPS and all it stands for.

The ARAC ETOPS WG task statement, however, required the WG to develop requirements for extended range operations for other than air carrier two-engine airplanes and also for air carrier two-engine airplanes beyond 180 minutes. The WG struggled with naming these "other" extended range operations. Early in the WG deliberations, a proposal was made to call them LROPS (Long Range OPerationS), and the WG group agreed. That term was being used by others in a similar context, so harmonization seemed to be served. However, during subsequent efforts to draft the new regulatory requirements, the drafters found it awkward to try to apply two different terms, ETOPS and LROPS, to operations of two-engine airplanes based only upon whether or not the operation was less than or more than 180 minutes. Furthermore, the air carrier maintenance community expressed great concern that the introduction of the new term LROPS would introduce unnecessary confusion among maintenance technicians and require equally unnecessary amendments to maintenance manuals and training programs. They noted how deeply engrained ETOPS has become over the years, not just the term, but more importantly, ETOPS programs and the commitment to increased safety and reliability levels brought about by those programs. It became evident that there was a perhaps unusually high level of pride in ETOPS, and a great reluctance to do anything that would dilute or compromise that. Moreover, there was a strong feeling that the valuable ETOPS experience should be capitalized upon by sharing it with other operations.

In the end, the WG decided that the best results could be achieved by capturing the familiarity, respect, pride and commitment associated with the term ETOPS, applying it to all extended range operations. While all ETOPS requirements are not the same, the differing requirements are specified according to the number of airplane engines and by levels of requirements based upon diversion time, as has been done for years.

Section-by-Section Discussion of the Proposals

The material contained in the proposed Airplane Type Design Rule (Part 25) and AC is a compilation of the existing AC120-42A, 777 Special Condition, and JAA Information Leaflet IL20. Since the AC and IL are advisory in nature, and the 777 Special Condition was written exclusively for the 777 airplane, the rule as developed by the ARAC ETOPS WG does not and cannot lift the material in these documents "wholesale." Rather, the rule prescribes as best as possible the intent of these documents, and greater amplification is provided in the draft Advisory Circular. The following discussion takes each of the Rule sections and attempts to capture all of the comments and discussion from the ARAC activities.

14 CFR 1.1 General Definitions

Recommendation:

Add definitions for the following acronyms and terminology associated with ETOPS:

Extended Operations (ETOPS).
In-flight shutdown (IFSD).
Early ETOPS.
ETOPS Configuration, Maintenance and Procedures Standard (CMP).
ETOPS Significant Systems. This definition includes definitions for Group 1 and Group 2 systems; depending on whether that system has a relationship to the number of engines on the airplane, or is independent of the number of engines.

Rationale:

These definitions have been determined by the ETOPS WG to be required to fully cover the tasking statement.

Furthermore, regarding the term ETOPS, AC 120-42A defined ETOPS in 1988 as *Extended-Range Operations With Two-Engine Airplanes*. Reflecting the application of the ETOPS concept beyond twin-engine airplanes, ETOPS is now redefined as

Extended Operations to embrace all such use of turbine-powered airplanes regardless of number of engines.

Extended operations are those in which the airplane under its proposed flight plan will be at some point more than 60 minutes (two-engine airplanes) or 180 minutes (three- and four-engine airplanes) flying time from an adequate airport at an approved one-engine-inoperative cruise speed under standard conditions in still air.

Use of the acronym LROPS *(Long-Range Operations)* was proposed to define operations beyond 180 minutes of an adequate airport for all airplanes regardless of the number of engines. As proposed, twin-engine extended operations up to 180 minutes would be called ETOPS and all operations beyond 180 minutes-twinjets included-would then be called LROPS. This proposal created unacceptable difficulties for the airline maintenance community because, although ETOPS and LROPS maintenance programs would be identical, the change in acronym would require operators to invest in additional training and documentation.

Alternatively, it was proposed that ETOPS be used to describe all operations beyond 60 minutes with twin-engine airplanes, and LROPS be used to describe all operations beyond 180 minutes with three- and four-engine airplanes. However, the ARAC ETOPS Working Group concluded that (1) the concept of precluding diversions, and protecting the diversion if it does occur, applies to *all* airplanes; (2) the capabilities of airplanes allowed to operate beyond 180 minutes are comparable; and (3) the maintenance and operational practices for all airplanes operating beyond 180 minutes are the same. It was felt that a single name should address their operation.

Some operators want a single name because two names imply special requirements due to the number of engines, whereas in fact the requirements are based solely on the type of operation and are uniform. Therefore, they felt that all extended operations should have the same name.

The operators also expressed concerns about the term *Long-Range Operations* (LROPS) because it closely resembles the term *Ultra-Long Range Operations*, which deals primarily with flight crew duty time, crew rest, and other human factors issues, and thus could be misleading.

After reviewing all these points of view, the Working Group came to a consensus on use of the acronym ETOPS as redefined to mean Extended Operations. ETOPS will be defined as the approved operation of turbine-powered airplanes when a portion of the flight is more than 60 minutes from an adequate airport for airplanes with two engines, or more than 180 minutes from an adequate airport for airplanes with more than two engines.

14 CFR 21.4 --- ETOPS Reporting Requirements

Recommendation:
Add a new regulation consisting of two parts, the Early ETOPS Problem Reporting & Tracking for all ETOPS airplanes, and ETOPS Operational Service Reliability Reporting for twin-engine airplanes.

Rationale:
1. The proposed rule is a codification of what ARAC considers to be one of the essential and objective elements of the early ETOPS Special Conditions (SC) for the B777 aircraft specifically pertaining to problem tracking and reporting. To quote the SC: "The major elements of the early ETOPS type design approval process defined in these special conditions include..... ***a problem tracking system***, ..." And, specifically pertaining to early ETOPS problem reporting: ".....problems occurring after the airplane begins ETOPS operations must be promptly reported in order that the FAA may require appropriate corrective actions. This requirement ensures that the risk of additional occurrences of any unforeseen failures that could affect the safety of ETOPS operations is low...." The ARAC ETOPS WG proposes the rule language contained in the new Section 21.4 which contains the essential elements of this early ETOPS problem reporting system; i.e., the Type Certificate holder must establish a reporting system. The system must contain a means for the prompt identification of those problems that could impact the safety of ETOPS operations in order that they may be resolved in a timely manner. The system must contain the process for the timely notification to the responsible FAA office of all relevant problems encountered, and corrective actions deemed necessary. Provide for appropriate FAA review of all planned corrective actions. The system must be in place for the first 250,000 engine-hours of fleet operating experience after the airplane enters service. For twin-engine ETOPS airplanes the system must remain in effect beyond 250,000 engine-hours of fleet operating experience until the fleet has demonstrated a stable IFSD rate, as specified in the rule, consistent with the approved diversion time of the aircraft. For the service period, this system must define the sources and content of in-service data that will be made available to the TC holder in support of the problem tracking system. The content of the data provided must include the data necessary to evaluate the specific cause of all service events reportable under Sec. 21.3(c) of part 21, in addition to any other failure or malfunction that could affect the safety of ETOPS operation. Ten event occurrences, specifically defined with respect to reliable, safe ETOPS operation, that require reporting are defined in the rule.

2. In addition, in paragraph (b)(1) of the proposed Section 21.4, the ARAC ETOPS WG proposes to require engine and airplane manufacturers to report periodically on the reliability of their twin-engine airplane fleets. Reporting includes: IFSD events, IFSD rates, and ETOPS fleet statistics. This reporting may be combined with the reporting required by Section 21.3. The proposed rule also requires the identification of cause and appropriate corrective action to assure reliable, safe ETOPS operations.

The periodic reporting of the reliability that is required of the manufacturers of engines and airplanes approved for ETOPS service begins at the service introduction of the product and continues throughout its product life. The interval of the reporting is more frequent early in it's product cycle and generally longer intervals are acceptable later in its product service life especially after the product has achieved maturity with regard to engine reliability (a stable engine shutdown event rate at or below the target values).

Generally the early product service life reporting on a quarterly basis is adequate, especially considering the fact that the manufacturers report engine failure events as they occur under the requirements of 14 CFR 21.3. Because early in its service life cycle the fleet is growing both in numbers of engine-airplane combinations in service, but with a the slow accumulation of engine flight hours, event rates may fluctuate considerably. Typically event rates are not very stable when the fleet cumulative time is less than 1 or 2 million engine flight hours. Therefore the focus should be on event occurrences, not failure rates, with a small fleet typical of early service time. Reporting at quarterly intervals is satisfactory as discussed above during the product's early service years.

After maturity (a stable engine shutdown event rate at or below the target values) with a large fleet, reporting intervals continues on a quarterly basis. Regardless of fleet size, fleet age, and its state of maturity, engine failures are reported under the requirements of 14 CFR 21.3.

Paragraph (b)(2) of the proposed Section 21.4 identifies world fleet IFSD rate/reliability requirements as follows: 1. IFSD rates compatible with the current FAA ETOPS AC and Policy for operation up to 180 minutes (including North Pacific operation); and 2. an IFSD rate compatible with operation beyond 180 minutes to 240 minutes and beyond, as contained in the proposed Operational rule and guidance material. As discussed in this proposed NPRM, an IFSD rate of .01/1000EFH is consistent with an extremely improbable risk of a dual in-flight power loss from independent causes for unlimited diversion capability of a twin-engine airplane.

Paragraph (b)(3) of the proposed Section 21.4 requires the FAA to conduct a technical review of events and corrective action should world-wide fleet rates exceed the rates specified in Section 21.4(b)(2) to determine if an unsafe condition exists. The rates given are not operator specific, but rather apply across the fleet of a given airplane-engine combination.

The FAA expects that manufacturer recommendations/corrective action to the fleet or regulatory action via an Airworthiness Directive(s) (in the event of a FAA declared unsafe condition) will continue to maintain an acceptable in-flight shutdown rate below the required levels. This is borne out by the current ETOPS fleet in-flight shutdown rates, which have achieved and consistently maintained rates at or below .01 per 1000 engine-hours. If this normal airworthiness monitoring process is not sufficient by itself to maintain an acceptable propulsion system reliability for a particular airplane-engine combination, then §21.4(c) will allow the FAA to require additional corrective actions, or reduce or withdraw the ETOPS diversion authority, if the risk of dual power loss is unacceptably high. Before such action is taken, however, the certificate holder and the FAA will assess the fleet-wide risk based upon the risk model developed for ETOPS presented in this preamble.

14 CFR 25.857 - Cargo fire suppression.

Recommendation:
Revise this regulation to require manufacturers of all airplanes that fly ETOPS to publish the capability of the cargo fire suppression system in the AFM. This will in all likelihood become the limiting factor of ETOPS flight for a particular airplane/engine combination. The AC allows applicants to use an all engines operative speed, since the probability of a cargo fire plus an engine out is less than extremely improbable.

Rationale:
The consensus with the ARAC ETOPS WG was that current ETOPS practice up to 180 minutes should remain unchanged, i.e. cargo fire suppression capability for the maximum single engine diversion time plus 15 minutes for approach and landing, e.g. 195 minute capability is required for 180 minute ETOPS approval. For operations beyond 180 minutes, it was considered prudent to consider winds, but because of the independence of an engine inoperative event and a cargo fire, an all engines operative speed could be assumed for a cargo fire related diversion. In all likelihood, actual ETOPS operations beyond 180 minutes would be limited by cargo fire suppression capability. The contingency for approach and landing of 15 minutes would still be applied. This will require the airplane design to take into account predicted winds in the determination of how much fire suppression capability will be provided.

14 CFR 25.1535 - ETOPS Approval

Recommendation:
This new rule in the body of Part 25 is effectively a pointer to Appendix L. Additionally, it requires the applicant to assess all Part 25 rules considering the maximum mission and crew workload. An example, obviously, is 25.1309 where numerical probability analyses are used to assess system design. Other not so obvious rules that would be impacted are 25.1011(b), oil endurance, and rules governing structural crack growth and propagation/fatigue.

Rationale:
This rule is crucial to assure that throughout the airplane design, the mission is properly considered, and the standard of compliance will be necessarily high. The "ETOPS Scenario" diagram and the ETOPS significant systems definition in the AC are good tools to all system designers to assure that all conditions have been assessed. There are additional requirements in Appendix L to provide focus on those airplane systems that have, historically, been important to ETOPS operations such as electrical power, APU and fuel systems. The emphasis on these specific airplane systems is not meant to be an indication that these are the only airplane systems that are important to ETOPS. The 14 CFR 25.1535 and Appendix L requirements along with the advisory circular guidance such as the ETOPS significant systems definitions, and the ETOPS scenario will ensure those other airplane systems can be adequately assessed for ETOPS.

Appendix L Extended Operations (ETOPS)

Recommendation:
Add a new appendix (L) to 14CFR Part 25 to set forth requirements for airplane type design for extended operations (ETOPS).

Rationale:

L25.2 Design Requirements

a) Operation in icing conditions

1) No ETOPS airplane can be certified without being certified for operation in icing condition; this rule closes the "loophole" which could have allowed this situation.
2) Continued safe flight and landing at the decompression altitudes is required. This rule will require the applicant to demonstrate to the FAA that the anti-icing systems on the airplane will assure the airplane's capability to continue to operate during a worst-case diversion, or if anti-icing cannot be shown to be available for all scenarios, that the diversion will be accomplished safely. It will also require the applicant to demonstrate that the non-heated (or "non-deiced") areas of the airplane will not pick up a load of ice that would make the airplane uncontrollable or create too much drag to complete the diversion. The AC is worded to allow the applicant to develop analyses or testing that would preclude having to show the entire diversion in icing. The Part 121 rule contains a similar allowance.

b) Electrical Power Supply

On a twin, the potential lack of redundancy available *vis a vis* electrical power makes this requirement especially important. There are considerations that must be taken into consideration such as:

1) Defining the critical systems powered by electricity
2) Dealing with the MMEL (to assure that there will be no dispatch with less than three generators for twin-engine airplanes operating beyond 120 minutes, and for 3 and 4 engine airplanes operating beyond 180 minutes).
3) Specifying the number of generators required (a la AC120-42A).

The rule section reads:

iii) *The electrical power supply system must be designed so that -*

(1) *The occurrence of any failure condition which would prevent the continued safe flight and landing of the airplane on an ETOPS flight is extremely improbable, and*

(2) *The occurrence of any other failure conditions which would reduce the capability of the airplane or the ability of the crew to cope with adverse operating conditions on an ETOPS flight is improbable*

(3) For airplanes to be certificated for usage on routes further than 180 minutes from a suitable airport, the airplane must be equipped with at least three independent electrical generation sources.

Sections (1) and (2) are required to assure proper redundancy and focus on power reliability, but the new emphasis is in paragraph (2). It will be up to the applicant to demonstrate which functions would "reduce the capability of the airplane or the ability of the crew to cope with adverse operating conditions…." It is not practical, for instance, for an applicant to state that operating for an extended period of time on suction feed would not reduce the capability of the airplane to cope with adverse operating conditions (negative g, turbulence, etc.). Additionally, the navigation and communication systems would have to be addressed by the applicant. As is pointed out in the AC, there is significant amplification on what systems would need to remain powered with today's airplane system architecture.

The issue of specific requirements for the number of generators, is highlighted by the paragraph (3) requirement to have at least 3 for operations beyond 180 minutes ETOPS. This topic is inextricably linked to the discussion about MMELs. There is concern that without a specific number of generators required in the rule, the MMEL could strip away some of the redundancy required for long range flight. The arguments against a prescriptive number are generally as follows:

1) Defining a number of generators would not assure proper system reliability (what's better: three generators with an MTBF of 20,000 hours each, or four generators with an MTBF of 3,000 each?)
2) Defining a number of generators would either artificially constrain or give a "pass" to future airplane designs. For instance, if a new airplane had a system architectural need for 8 generating systems, requiring three in the ETOPS rule would not assure an adequately safe design.
3) Trying to address the formation of the MMEL in Part 25 is impractical and inconsistent with agreed- to policies for MMEL development. Nonetheless, it was agreed that there should be a tie-in between the analysis performed for Part 25 ETOPS approval and the analysis the Flight Operations Evaluation Review Board (FOEB), who develop the

MMEL, used in determining dispatch criteria. This is almost always the case in today's process, but formalizing the process would be a positive step.

Therefore, an additional paragraph has been added to the ETOPS regulation to require a minimum number of electrical generators. This requirement codifies the existing AC 120-42A electrical generator redundancy criteria. The intent of this requirement is to ensure future airplanes to be certified for ETOPS have an electrical generation system architecture equivalent to the 737, 757, 767, 777 and A310, 320, A330 era airplanes. The FAA recognizes future airplane electrical system architectures may be significantly different from today's airplanes, but the architecture must be equivalent from the perspective of robustness to independent failure scenarios.

c) Fuel System Design

As recent events show, the design of the fuel system, and the ability of the crew to properly deal with a malfunction are arguably the most important issues facing the designer of ETOPS airplanes. Three sections of the rule (with corresponding AC guidance) address:

1) Assurance of positive fuel pressure at the engine fuel pump (no suction feed)
2) Adequate fuel must be available for any failure scenario (no hidden/trapped fuel, functional crossfeed valves, etc.), and
3) Proper flight deck alerts.

There has been some discussion regarding newer generation airplanes (B777) and their system architecture being the standard by which operations beyond 180 minutes will be judged. Currently, all transport category aircraft are required to perform suction feed testing as part of the basic Part 25 certification, which requires the applicant to simulate an all AC power loss at the service ceiling of the airplane. The testing is performed to assure that in the event of an all AC power loss, there is still ability (at some safe altitude) to re-start the engines on suction feed, (if a flameout occurs), and generate thrust to a safe landing. Despite the belief that proper testing could be put in place to assure proper long duration operation on suction feed, technology exists and has been designed into current aircraft that precludes that possibility; therefore, "state of the art" dictates that future designs should also assure that continued operation on suction feed is not a practical possibility on ETOPS airplanes. Regulation L25.2.b.i is applicable to all ETOPS airplanes irrespective of the number of engines.

Additionally, the new rule tightens up the standard for crossfeed reliability and "unusable" fuel in order to assure that there is never a loss of the remaining engines due to trapped fuel.

Flight deck alerts are also emphasized, and the AC speaks at length about the types of alerts which are considered critical based upon fuel loss events in the current generation of aircraft.

An additional fuel feed capability requirement has been added for twin-engine ETOPS operations beyond 180 minutes. The requirement is meant to address the concerns for fuel availability raised in the development of the FAA 207 minute ETOPS policy. The requirement requires a fuel boost pump in each main tank and actuation capability of at least one crossfeed valve powered by a back-up electrical generation source other than the primary engine driven or APU driven generators, unless the required fuel boost pressure or crossfeed valve actuation is not provided by electrical power.

d) APU Design/Function

As stated in the AC, current twin engine aircraft can only comply with the requirements of electrical reliability by having three generators; this has been accomplished by the use of the APU. This section of the rule requires that if the applicant is going to rely on the APU for electrical power that

1) The APU has to have adequate reliability,
2) If there is a dependency on starting and running the APU inflight, the APU should start and run to the maximum operating altitude of the airplane, but need not exceed 45,000 feet.

The major reason for wanting high altitude APU inflight start capability is to avoid having flight level changes that would cause the flight to have to cross through established flight track systems just to start the APU. Also, once the flight leaves the established track system it can be very difficult, or impossible to re-enter the track system, reducing the pilot's flexibility to fly the optimum flight plan. Having an inflight start capability up to 45,000 feet mitigates these concerns.

"Adequate" reliability consumed much of the WG's discussion time during development of the rule. This term can only be placed in context by understanding the overall electrical and pneumatic system architecture of the airplane. For instance, if an applicant has installed generators with inadequate reliability, their MTBF may require and extremely reliable APU generator, driving the applicant to a significant demonstration program. The reverse could also be true - an electrical system may have generators with an excellent MTBF of 100,000 hours, and additional non-APU back-up sources - thus the "required" reliability of the APU would be less than today's standards. It is not practical to assume that any aircraft utilizing credit for an APU installation would be allowed to have a lower standard of reliability than currently exists.

The APU has traditionally been utilized only for electrical system "back-up" reliability, and the new regulatory and advisory material focuses on this function. No current aircraft utilizes the APU installation to provide "back-up" pneumatic system capability to meet ETOPS significant system reliability standards. However, the possible operational need for APU pneumatics on the ground in a divert scenario to satisfy the group 2 (vii) definition is addressed in the advisory circular. If the APU was necessary as a bleed source to comply with 14CFR25.1309 or the new 14CFR25.1535, an envelope definition of where it can perform its intended function may be required. Currently most APU's can only provide both bleed air and electrical power at lower cruise altitudes, and cannot provide enough bleed air to power an air conditioning pack at the aircrafts service ceiling. The use of a "limited" APU operating envelope must be fully accounted for in complying with 14CFR25.1309 or 14CFR25.1535 analyses. Likewise, the previous comments regarding the APU's overall reliability to today's standard would still apply.

e) Relevant Experience, or "Lessons Learned" for Early ETOPS

One of the five key elements of early ETOPS on the B777 was the Relevant Experience Assessment, or Lessons Learned. Simply stated, the intent is for the applicant that wishes to achieve early ETOPS on an airplane/engine combination to review the failures on previous airplane/engine combinations, and assure that the causes of those failures are mitigated. While simple in concept, the execution of this assessment is significant in scope. One of the most significant aspects of this rule is that an applicant with no previous transport category manufacturing experience is not eligible to receive early ETOPS approval. The relevant experience assessment is considered elemental to early ETOPS; without the ability to perform this assessment (including lessons learned on manufacturing and engineering processes) early ETOPS could not confidently be granted.

> Beyond a certain level of commonality, past experience may not be relevant to a new design. This is particularly true where a specific design feature that contributed to problems in previous airplanes is not a part of the new airplane design. However, the demonstration of the applicability of past experience to the new design is inherent in the relevant experience assessment. This rule section requires that corrective actions taken to preclude similar problems from occurring on the new airplane must be identified. Removal from the design of a system, sub-system, or component that has had problems in the past may be an acceptable corrective action, as long as it precludes similar problems from occurring. Where new technology is introduced, the lessons learned assessment becomes impractical, as there is no previous experience with this technology. While this is true, there may still be applicable relevant experience. For example, an applicant's previous experience with new technology introductions may lead to changes in manufacturing and quality control processes. Further, lessons learned of general applicability can be introduced into the new technology design, such as a general design practice to prevent cross-connector installation.

As stated above, there may be applicable relevant experience even for a completely new design incorporating new technology.

f) In flight shutdown prediction

This rule section requires that the propulsion system be designed to preclude failures and malfunctions that could result in an engine inflight shutdown. Propulsion systems on previous airplanes were designed and certified to be "fail-safe," in compliance with § 25.901 of part 25; in other words, any single failure, or probable combination of failures, would not jeopardize continued safe flight and landing of the airplane. Because safe flight following an engine shutdown is required by part 25, preventing engine inflight shutdowns has not been a major design objective on some previous airplane designs. The additional design requirement in this section to preclude failures and malfunctions that could result in an engine inflight shutdown has an enormous effect on propulsion system reliability in that normal design decisions must now consider whether a failure or malfunction might result in an engine inflight shutdown. The method of compliance to this section may vary from applicant to applicant, but the intent remains -- all design features of the propulsion system must preclude shutdowns or power losses. This intent is also captured in the proposed Part 33 rule.

g) In-Service Validation

This section is lifted entirely from the existing AC 120-42A, and is identical in context. The IFSD targets are provided in the new 14 CFR §21.4, "ETOPS Reporting Requirements" regulation.

h) Early ETOPS Validation

This section captures and expands on several key elements of the B777 Special Conditions.

1) **"Type and Frequency" Requirement**.

Statistical confidence of an airplane/engine combination reliability cannot be shown during a reasonable flight test program, and neither does a small number of failures during the flight test program suggest high in-service reliability due to the small sample from which to base a failure rate calculation with a high degree of confidence. However, there is a positive correlation in that the occurrence of a higher number of basic design problems during type certification testing generally has resulted in a higher number of problems occurring after the airplane entered service. Those airplanes with the best propulsion system reliability after entry into service have also, in general, encountered fewer design problems during the type certification program.

Even without the possibility of gaining statistical confidence during a flight test program, experience has also shown that in general, predictions of mature component reliability made in analyses for showing compliance with the safety assessment requirements § 25.1309 of the FAR have been conservative when compared with the actual achieved reliability in service. In most cases, the types of problems that prevent a system or component from achieving the predicted, mature level of reliability have been basic design or manufacturing deficiencies that could have been detected if extensive enough testing had been accomplished during development and certification prior to entry into service. Random type failures have not been a major contributor to unreliability. Therefore, this rule section allows for a final "go/no-go" gate for the FAA to determine whether the problems encountered during a flight test program constitute a basic design problem or are consistent with the type and frequency of failures that would be expected to occur on certified ETOPS airplanes or engines. FAA is confident that a design will achieve a high level of reliability based on development and certification test results, provided the testing is thorough in evaluating all potential failure sources. The ETOPS rule's relevant experience, analysis, and test requirements define the methods that must be used to accomplish a thorough evaluation of failure sources.

2) Engine Testing

This section is largely a "pointer" to the requirements to perform an engine cyclic endurance test in FAR Part 33. The need for this section in the rule is to assure that the entire propulsion system (engine accessories, nacelle, thrust reverser, etc.) is installed on the test vehicle. Since Part 33 speaks only to the "basic" engine, this rule section is required.

3) APU Testing

As previously stated, the current generation of twin-engine airplanes must rely upon the electrical generation capability of the auxiliary power unit. To assure proper reliability at entry into service, the APU must undergo endurance testing in a similar manner to the main engines. The phrase "equivalent airplane operational cycles" requires the applicant to demonstrate to the FAA that the APU has been adequately demonstrated under simulated airline operation; in most cases this will include cold-soak and high temperature cycles, and simulated pneumatic and electrical loads. Further amplification of the interpretation of "equivalent airplane operational cycles" is found in the draft AC.

4) Airplane Testing

The early ETOPS Special Conditions for the B777 required that for each engine type, an airplane demonstration test of 1,000 cycles must be accomplished on one airplane. The 1000 cycle airplane validation test requirement was developed with the intent of exposing the airplane to the conditions where the greatest number of inflight shutdowns would occur. Since most inflight shutdowns typically occur during the early part of a flight, i.e. takeoff and climb, the failure modes associated with these shutdowns tend to be cyclic in nature for a couple of reasons. For failure modes where the risk of failure increases with engine thrust, the takeoff portion of the flight is most critical. Failure modes that occur due to improper maintenance or engine servicing, e.g. loss of engine oil due to improper assembly of an oil tube connection, also tend to occur early in the flight. A larger number of airplane flights increases the exposure to these types of failures. Therefore, the FAA considered that a cyclic test was the most appropriate airplane validation test requirement for the 777 ETOPS special conditions.

In the preamble to the B777 Early ETOPS Special Conditions, the FAA stated that:

". . .existing practices to achieve airplane certification safety objectives have involved definition of performance requirements, incorporation of safety margins,

and prediction of failure probabilities through analysis and test. However, historical evidence, in general, indicates that a period of actual revenue service experience is necessary to identify and resolve problems not observed during the normal certification process. Successful achievement of this experience has been a prerequisite for granting ETOPS type design approval for a specific airplane engine combination. However, several recent airplane engine combinations incorporating new or substantially modified propulsion systems have demonstrated a high level of reliability consistent with ETOPS operation upon entry into revenue service. In addition, this high level of reliability was demonstrated by the small number of problems encountered during basic certification activity."

Based on these successful airplane and engine development and certification programs (i.e., 767/CF6-80C2, A320/CFM56-5, etc), the special conditions were designed to

> *". . .result in a level of airplane reliability that is equivalent to the level of reliability previously found to be acceptable based upon service experience."*

Upon review of the data gathered from the 1K airplane and 3K engine tests, it is now considered that the 3000 cycle engine and propulsion system test currently required by the new draft Part 33 engine rule provides an adequate opportunity to discover cyclic related failure modes associated with the design. This has been verified by the three baseline engine programs conducted in accordance with the B777 Early ETOPS Special Conditions. Review of the test data has shown that most of the early in-service 777 failure modes could have been discovered had Boeing and the engine manufacturers conducted a more detailed teardown inspection and analysis of the 3000 cycle test engine and propulsion system hardware.

For inflight shutdowns where improper maintenance is a main causal factor, the 1000 cycle airplane demonstration test provides multiple opportunities for these types of failures to occur, however, the maintenance procedure validation program required by the new regulation is intended to minimize the probability of these occurrences. The airplane demonstration flight test airplane provides opportunities to demonstrate those maintenance tasks associated with the normal operation of the airplane.
Although the fewest number of inflight shutdowns occur during cruise, this is the phase of flight that is most important to an ETOPS operation. Traditionally, the FAA and industry have avoided trying to differentiate between those inflight shutdowns that may occur during cruise from those that would only occur in a non-ETOPS environment. The main reason for this approach in existing ETOPS policy is that by correcting all causes of inflight shutdowns, the overall integrity of the propulsion system is assured. Since adequate cyclic exposure would be provided by an enhanced 3000 cycle engine demonstration test required by the draft Part 33 Rule, the airplane validation program should provide more exposure to the cruise phase of flight than was accomplished during the three 1000 cycle tests conducted for the original 777 engine installation certification programs. During those tests, only 91 of the total 1000 cycles were of durations of two hours or more. Since the intent of this rule

section is to simulate an actual airline operation, this would better be accomplished through longer duration flight cycles. This long duration flight exposure provides additional confidence in the design against those cruise related failure modes that cannot be evaluated in a cyclic test environment. These could include cold-soak freezing of entrapped water condensation, or binding of propulsion system components that do not occur in a sea level test facility.

Based on these considerations, the airplane validation program has been refocused on those conditions that are most prevalent in an ETOPS operating environment. These conditions include long flights to a variety of airports with broad variations of airport elevation, temperature, and humidity. It is also important that these flights expose the airplane to several enroute climbs, such as may occur with a fully loaded airplane on a long range flight, and a number of engine-out diversions.

Since this test is not specifically a test of engine reliability, this rule section is applicable to all airplanes regardless of the number of engines.

i) Problem Tracking and Reporting System

This section is divided into two parts: the problem tracking/reporting required during the certification testing, and that required during the "early ETOPS" period of the first 250,000 hours of operation on type. The latter requirement is captured in the new draft rule 14 CFR Part 21.4. In determining the importance of this rule section, a review of experience on the first early ETOPS airplane is necessary.

The Model 777-200 powered by Pratt & Whitney PW4077 engines was approved for ETOPS on May 30, 1995 and entered service in June 1995. By all accounts, it was a very successful new model introduction. This was followed by the ETOPS approval of the 777-200 powered by General Electric GE90-77B and Rolls-Royce RB211-Trent 877-17 engines in October 1996. Based on data supplied by Boeing, the inflight shutdown (IFSD) rate for all three engine types was zero for at least the first year in service. The Pratt & Whitney PW4000 reached a peak 12 month rolling average IFSD rate of .018/1000 hours in October 1996. The General Electric GE90 reached a peak of .021 for one month in July 1998 and the Rolls-Royce Trent reached a peak of .016 in December 1997. Although the inflight shutdown rates stayed within the allowable .02/1000 hour standard for 180 minute ETOPS, design problems were discovered on each engine type after ETOPS approval.

During the first two years after ETOPS approval of each engine type on the 777, the FAA was concerned that the design problems being discovered may have been an indication of a failure of the early ETOPS process to identify these failure modes before they occurred in service; Boeing and the engine manufacturers explained that 1), the process was not intended to eliminate ALL failures, and 2) the problem tracking system was one of the key elements of early ETOPS. Some failure modes had the potential of resulting in inflight shutdowns had they occurred under different circumstances or had not been detected during maintenance for unassociated reasons. Had every one of these events resulted in an engine inflight shutdown, the resulting IFSD rates for each engine type would have been significantly higher. However, Boeing, the engine manufacturers, the FAA, the airlines, and other regulatory authorities worked together to prevent additional in-flight occurrences of these failure types. The actual inflight shutdown rates prove that these early in-service problems were successfully managed to maintain the safety of B777 ETOPS operations worldwide. *A robust problem tracking, reporting, and resolution process was key to the continued safe operation of the B777 and will be a critical component to future applications*.

j) Maintenance and Operational Procedures Validation

During the certification of the B777 for early ETOPS, the Special Conditions required that the 1,000 cycle demonstration test be conducted using the airline maintenance and operations manuals. The purpose of this requirement was three-fold: 1) to assure that the 1K test was as close to an airline simulation as possible, 2), to assure that the maintenance and operations products were mature at entry into service, and 3), to assure that no maintenance or operations procedures would erroneously contribute to system failures.

In developing this draft rule, there is full concurrence with the requirement to assure maintenance and operational product maturity at entry into service, but also recognizes that validation of these products can be accomplished in different fashions. Nonetheless, it should be noted that the AC recommends that for all testing necessary for ETOPS validation (component, engine and airplane), the maintenance manual should be used. Tasks such as LRU replacement, testing following removal/replacement of parts, etc., must be validated per the requirements of the rule. The AC does provide amplification, however, on what maintenance manual sections should be validated, namely only those sections pertinent to Groups 1 and 2 ETOPS significant systems. For instance, while validation of a landing gear maintenance task may be prudent for product readiness, the landing gear is not considered ETOPS critical, and therefore validation of related maintenance procedures is not required.

k) Combined Validation

The rationale for the combined approach is the precedents established by the Airbus A330 and Boeing 737 "Next Generation" aircraft. In the case of the Boeing 737, the FAA concurred with the Boeing proposal, which stated that by following the early-ETOPS processes (short of performing a dedicated flight test), an accumulation of 15,000 fleet hours would be adequate to demonstrate suitability for 180 minute ETOPS. This was based upon:

- A validation program which included all aspects of the 777 early ETOPS special condition except for a dedicated airplane flight test, i.e.,
    - Relevant experience assessment

- Propulsion system 3000 cycle ground test
- Problem tracking and resolution
- Maintenance and operations procedures validation

· The allowance granted by AC 120-42A to reduce the service experience requirement
· The excellent reliability during flight testing
· Diversion experience (3 diversions of 180 minutes on a single engine) during the Functional & Reliability (F&R) testing
· The proven ability of Boeing to satisfactorily manage ETOPS airworthiness (based upon B777 experience).

Appendix L25.4(c)(ii) also allows the in-service experience requirements of paragraph L25.4(a) to be reduced provided compensating factors provide an equivalent level of safety. The intent is that the compensating factors are bounded by the in service requirements of paragraph L25.4a) and the early ETOPS validation prescribed by paragraph L25.4b) and L25.3.

The first IFSD on the 737 “NG” did not occur until 30,000 fleet hours had been accrued. It must also be noted that several IFSD’s occurred in quick succession such that the rate exceeded that necessary for 180 minute ETOPS. The FAA ultimately granted 180 minute approval on the 737NG 12 months after EIS, after approximately 300,000 fleet hours had been accrued.

The experience of the 737NG supports the “combined validation” methodology provided in this draft rule.

14CFR 33.90, Initial Maintenance Inspections *(revised)*

Recommendation:

The current rule Section 33.90 identifies a test requirement for an applicant for a new engine being certificated by the FAA for the purpose of establishing when initial maintenance inspection is required. This rule does not apply to applications for an amendment to an existing type certificate, or for supplemental type certification procedures.

The ARAC group proposes to revise this rule by adding a test requirement for applicants seeking to certify a new engine for early ETOPS that does not have the requisite service experience.

The current requirement (Section 33.90, otherwise known as Initial Maintenance Inspection) becomes Section 33.90(a); the early ETOPS test requirement (new) becomes Section 33.90(b).

The test requirement for early ETOPS (Section 33.90(b) is a rigorous test consisting of 3000 cycles of simulated service-mission operation conducted at a level of vibration that is far above the level/duration (cycles) reasonably expected to occur in service. The test also includes three demonstrations of single engine diversions at max continuous thrust for the maximum duration (time) for which the applicant seeks approval.

The revised rule language retains the verbiage "... engine which substantially conforms to the final type design" as shown below in the current rule:

> Sec. 33.90 Initial maintenance inspection.
> Each engine, except engines being type certificated through amendment of an existing type certificate or through supplemental type certification procedures, must undergo an approved test run that simulates the conditions in which the engine is expected to operate in service, including typical start-stop cycles, to establish when the initial maintenance inspection is required. The test run must be accomplished on an engine which substantially conforms to the final type design.
> [Amdt. 33-10, 49 FR 6854, Feb. 23, 1984]

The proposed rule (14 CFR 33.90) retains this language to assure that the engine used for the 3000 cycle test of the proposed Section 33.90 rule does "substantially conform" as a system to the intended type design configuration for early ETOPS service.

Rationale:

The proposed rule (14 CFR Part 33.90(b)) is intended to both establish when the initial maintenance inspection is required (current rule Section 33.90) and to show suitability for early ETOPS for a twin-engine airplane. The early ETOPS engine test has been demonstrated via the B777 early ETOPS SC by the three major engine manufacturers to adequately substitute for actual in-service experience by the rigor of the simulated service cycle and the concurrent vibration test exposure.

The rule allows an applicant to conduct the test program on one engine to demonstrate compliance to both regulatory objectives. However, should an applicant choose to obtain Part 33 certification in advance of the completion of the full 3000 cycle test, it is permissible within the rule to conduct a complete borescope visual inspection of the engine at an interval during the 3000 cycle test equivalent to the IMI test requirement of the current Section 33.90 (proposed Section 33.90(a).

The regulation (Part 33, Appendix A, Instructions for Continued Airworthiness, A33.3(c)) also requires that the applicant define and validate a process for operators of twin engine ETOPS airplanes so that they are able to determine, prior to flight dispatch, when adequate thrust is not available for safe flight during a potential diversion and landing. This will assure that an airplane is not dispatched with engines that have thrust deterioration below certified levels.

14CFR 33.100, Early ETOPS Eligibility *(new)*

Recommendation:
This proposed regulation imposes requirements that the FAA administrator finds necessary for aircraft turbine engines for ETOPS twin-engine airplanes which, while not having the requisite amount of service experience traditionally expected for an FAA finding of suitability under Advisory Circular 120-42A, have been demonstrated to be

fully satisfactory under Special Conditions No. 25-ANM-84, Extended Range Operation of Boeing Model 777 Series Airplanes. This regulation essentially codifies the requirements for future applicant's seeking "early" ETOPS eligibility of turbine engines for Part 25 ETOPS twin-engine airplanes.

Rationale:
There are three means by which an engine can be found eligible for ETOPS for twin-engine airplanes; First is in-service experience, traditionally applied by Advisory Circular 120-42A; second, analysis and test without in-service experience, applied by the B777 early ETOPS Special Condition and the proposed new regulation. The third approach is a combination of in-service experience and analysis and test.

This regulation requires engine designers to use their best design practices, including all their corporate knowledge, skills, and lessons learned, to eliminate from the proposed design all known failures, malfunctions, or design related maintenance errors experienced in other engines early in service that are especially relevant to ETOPS, such as loss of thrust or shutdown. The regulation requires that engine designers show that these types of problems extended back into their design history for a period of ten years have been addressed in the engine for which early ETOPS eligibility is sought. By continuously building on the improved reliability seen in today's engines, the effect of this regulation will result in even higher levels of reliability in the future. The FAA recognizes that even with the advances in design and manufacturing technology, methods, process capability and reliability; loss of thrust or shutdown can occur. The intent of the regulation is to minimize the likelihood of an engine caused diversion, and to protect the safety of the airplane in the event of a diversion.

This regulation requires new testing for new engines for early ETOPS for twin-engine aircraft. This test was first mandated for the early ETOPS approval of the B777 under the FAA Early ETOPS Special Conditions. This test subjects a new engine to an accelerated exposure of simulated service operation typical of in-service operation for which ETOPS eligibility is sought. The test will expose the engine to possible failure modes not normally expected under the normal certification requirements of the current airworthiness standards. The test duration of 3000 cycles is based on the historical fact that the vast majority of problems that have resulted in engine shutdowns have occurred in initial service exposure (within 3000 cycles, or the first two years typically) on airplane-engine combinations found eligible by the FAA under the ETOPS Advisory Circular. Successful completion of this test gives the FAA confidence that the new engine has the requisite reliability for early ETOPS.

While the test was first imposed on B777 engines under the Early ETOPS Special Conditions, prior to and subsequent to the certification of the B777, other aircraft types with new engines, and other derivative engine types have successfully demonstrated the requisite level of reliability for ETOPS under normal certification procedures, or with some other test-service demonstrations, by very well qualified and experienced engine applicants. However, the FAA considers that new twin-engine airplane-engine combinations, based on the successful service introduction of the B777 are required to undergo this test to demonstrate the requisite reliability for early ETOPS.

The test requirement applies to new engines. For early ETOPS eligibility only, a new engine is defined as an engine which has new architecture in comparison with other engines of similar type designed by that applicant or an engine for which an application for a new type certificate is made in accordance with 14 CFR Part 21.15 or 21.19. The term "new architecture" refers to the engine's overall mechanical size and stiffness, static structure, dynamics, bearing arrangement, number of structural frames, mounting arrangement to aircraft, number of compression/turbine stages, size/diameter of the fan. An engine with changes to its architecture relative to another certified design may be required to conduct the early ETOPS test if the system dynamics of the engine are considered a major change from previous experience. In addition, an engine installed into a new aircraft application or installation (new to the engine), may require the test to demonstrate reliability of the propulsion system. A good technical understanding of the engine architecture and the aircraft installation is necessary to determine to what extent, if any, the test content requirements of the regulation are required for derivative engines and for major changes to certified engines for early ETOPS eligibility. The content of the test will be dependent upon the level of change from the baseline engine, considering also the vibratory characteristics of the airframe/engine combination.

By the regulation, the test is required for engines that will be used on twin-engine ETOPS airplanes rather than 3 and 4 engine airplanes. The reason is that the allowable IFSD rate to maintain safe flight and landing is an order of magnitude (10 times) greater for a tri- or quad-engine aircraft compared to a twin-engine aircraft.

The new test requirement builds on the current endurance test airworthiness standards of 14 CFR 33 (Section 33.87) by simulating both typical field service operation expected to be encountered in the first 250,000 hours of the fleet, or typically two years of service, and the extent of time that an engine will operate in the event of a diversion, at maximum continuous power for the longest diversion time expected. In addition, the test is required to be conducted at a level of vibration for the complete test that exceeds expected service exposure.

The new test is an important part of the early ETOPS eligibility determination for both the engine and propulsion system of the airplane. No other type of engine vibration testing can replace vibration induced by imbalance of its rotors running through the speed and power ranges experienced in service. The test is required to simulate 3000 cycles of service operation (typically two years) in a short time span. The vibration tests conducted for the original certification of the three engine types used on the B777 under the Special Conditions proved to be highly successful. Those tests were also a combination of engine cyclic endurance with high cycle fatigue (HCF) vibration induced by way of imbalancing the main rotors of the engine.

The table shown below summarizes the applicability of current and proposed ETOPS 14 CFR Part 33 requirements.

Engine regulations applicability matrix – current requirements and proposed ETOPS requirements

14 CFR	Engines intended for twin engine ETOPS airplanes	Engines intended for more than two engine ETOPS airplanes	Comment
Part 33	Applies...	Applies...	All current Part 33 regulations apply regardless of aircraft installation, based on the certification basis of the engine
New 33.100 introductory statement	Applies...	Not applicable...	Only if early ETOPS eligibility is sought by applicant
New 33.100(a)	Applies...	Not applicable...	Same as above
New 33.100(b)	Applies...	Not applicable	Same as above
33.90 introductory statement	Applies...	Applies...	To new type certificated engines only (slight wording changes versus current, no intent to change applicability)
33.90(a)	Applies...	Applies...	Same as above
New 33.90(b)	Applies...	Not applicable	To engines intended for twin-engine ETOPS airplane installations only
Part 33, Appendix A, A33.3 Content, new subparagraph c	Applies...	Not applicable	Same as above

14 CFR 121.7 Definitions *(new)*

Recommendation:

Add to 14 CFR 121 a new section with definitions applicable to ETOPS.

Rationale:

Many of the terms used in the proposed regulatory and guidance material for ETOPS under 14 CFR 121 are unique to these operations. Requirements and concepts for ETOPS require precise definition to assure common understanding and compliance.

14 CFR 121.97(b)(1)(ii) *(new)*

Recommendation:

Include in the interpretation of "public protection" in the listing of airport data required to be maintained by the certificate holder by 14 CFR 121.97 that such facilities include those available for public safety and for protection and welfare during regular and irregular operations, including diversions to the airport.

Rationale:

Airlines must consider passenger facilities when selecting an ETOPS alternate and in diversion planning. The facilities at an airport or in the immediate area must be sufficient to protect the passengers and crew from the elements and to see to their welfare during the time required to transport them onward.

By definition, ETOPS operations are those with long segments over water or remote areas. Some of these remote areas are affected by severe weather conditions such as, but not limited to, extreme cold or high winds and cold temperatures. Some of the airports that are well positioned for use as enroute alternates are in remote areas. These airports may have only limited or seasonal facilities that could be used to shelter passengers and crew after an unscheduled landing. As the scope of ETOPS operations has expanded and extended, operations over more remote areas with more extreme weather possibilities have become routine. Northern Canada and the Russian Far East are typical examples. Facilities at some of the airports in those areas have not been maintained because of political, economic and military changes. It cannot be assumed that the passengers and crew of an aircraft will be safe simply because a safe landing can be made at an airport. Therefore, certificate holders are obligated to be aware of the available facilities and satisfy themselves that there will be adequate facilities to protect the passengers and crew should it be necessary to make an unscheduled landing for any reason.

These are new requirements. The FAA is adding these additional requirements to this regulation because it has learned that not all certificate holders have planned for these contingencies in the past, apparently because the current wording of the regulation did not require them to do so. The FAA believes regulatory guidance is prudent to insure carriers recognize "the duty of an air carrier to provide service with the highest possible degree of safety in the public interest…" 49 U.S.C. sec. 44701 (d)(1)(A). In addition, some have argued that since ETOPS flights are generally international flights, treaties limit damages for negligence that passengers on international flights may recover from airlines. Further, absent the compelling motivation of unlimited liability for proven damages available to domestic passengers, carrier motivation to avoid findings of negligence may also be lessened somewhat.

Others have pointed out that in the Polar Policy letter the FAA has already included instructions and requirements detailing the treatment of passengers in case of diversions or accidents and the facilities to be made available for them. Further, the addition of passenger related contingencies are based on rules, regulations and International Treaties, which have been and are in the process of being enacted for the protection of passengers well being such as: "Aviation Disaster Family Assistance Act of 1996", The DOT/NTSB Task Force Report on Assistance to Families of Aviation Disasters of 1997, Public Law 105-148 of 1997 (105th Congress), ICAO Circular 285-AN166 (33rd Assembly, 2001), European Union Regulation (EG) 2027/97, the "Convention for the Unification of Certain Rules for International Carriage by Air" of 1999 and others. Providing for the safety, security, comfort and well being of all of the occupants of an airplane have especially become important on long range flights because of increasing medical consequences. It was also pointed out that ignoring those requirements expose the carriers to increasing liability claims and to loss of business because of passengers' discomfort.

The FAA believes that a higher level of government scrutiny and regulation of these operations is appropriate.

14 CFR 121.99(a) *(new)*

Recommendation:

Include in 14 CFR 121.99(a) communications facilities on routes and at altitudes that could be used to potential alternate airports. Include in 14 CFR 121.99(c) to add a requirement for reliable voice based communication.

Rationale:

Most airplanes operate in an environment where there is usually a choice of diversion airports available within a close proximity to the route of flight. The airplane conducting ETOPS may have only one alternate within a range dictated by the endurance of a particular airframe system (e.g., cargo fire suppressant) and therefore the approved maximum diversion time for that route. Diversions undertaken in such an environment will necessarily be for emergency situations such as an inflight fire, an airplane critical system failure, or a serious passenger problem. Such diversions, precipitated by abnormal events that either demand or warrant a deviation from the normal flight profile, will bring both the airplane and its passengers and crew under some level of stress during the diversion. As such, the flight crew will have the need of increased critical communications requirements during the diversion. Consequently the regulations should require adequate communications facilities on the routes to airports that could be used during diversion over the range of altitudes flown during diversion, including altitudes flown with an engine inoperative or in the event of cabin pressurization failure, as well as demand adequate communications capabilities for the flight crew.

Communications capabilities should be able to provide the flight crew with a clear, reliable and immediate link to both the ATC and company facilities. Such capability is crucial to support long-range operations in remote areas to support problem evaluation and preclude a diversion or to protect the aircraft and it's passengers during the diversion.

Voice communication is an essential element to such a strategy, providing the necessary immediate, two-way communication that assures no increased demands on pilot workload or crew coordination. The rule is intended to require voice communication over the route, including diversion routing, where voice communication is available. Another means of communication, such as data link may be used where voice communication is not possible. SATCOM voice communication systems introduced an enhanced level of reliability and capability over earlier systems in most areas of the world. It is therefore prudent to demand the most reliable communications technology to enhance the safety of all long-range operations beyond 180 minutes from an alternate. The rule is not intended to require an operator to continually upgrade existing installations on an incremental basis, but rather to provide the evolutionary communication improvements (e.g., SATCOM versus HF) on airplanes used for ETOPS beyond 180 minutes. The systems employed in some areas of the world may require different technologies than elsewhere in the world. As new technologies are introduced that significantly enhance the quality of voice based communication (e.g., SATCOM versus HF), the rule would require their employment where appropriate.

14 CFR 121.106 *(new)*

Recommendation:

Add a new regulation, 14 CFR 121.106, requiring a rescue fire fighting capability at an airport designated as an ETOPS alternate.

Rationale:

Currently, 14 CFR 139 does not require any aircraft rescue fire fighting (RFF) capability at airports designated as Takeoff and Destination alternates. Alternate airports are referred to in 14 CFR 139 but not defined. The common perception for alternate airport is that it is one, which is used infrequently. But the original use of the definition was limited to the destination or takeoff airports. There was no specific mention of the *en route* alternate until Advisory Circular 120-42, Extended Range Operation With Two Engine Airplanes (ETOPS), was issued in 1985. The airport regulations specified in 14 CFR 139 were first published in 1972 prior to the inception of ETOPS. For these reasons, and as outline further below, a new regulation 14 CFR 121.106 has been proposed to include the requirement for RFF at an en route alternate airport.

Normally a flight diverts to its destination alternate airport because of poor weather at the destination airport or the aircraft having a low fuel state. In contrast, a diversion to an ETOPS en route alternate is likely attributable to an engine or system failure or medical emergency. Throughout the ETOPS flight the designation of the en route alternate may be revised, with consideration of the designated en route alternate airport maintaining an adequate level of weather and runway conditions to safely land the airplane in the event that a diversion is necessary. At the most critical point of an ETOPS en route diversion there is no other choice as to the diversion airport. It remains necessary to ensure that all the facilities and services are adequate to ensure that a safe landing can be made at the diversion airport in the event that it is necessary to divert. Thus, some have argued that there is an increased importance of a rescue fire fighting service at airports designated as an ETOPS en route alternate. Further, they have argued that establishing such a requirement in the Federal Aviation Regulations is consistent with ICAO Annex 6, Part I, Attachment E, wherein an “adequate alternate aerodrome” is defined. The definition includes a list of various facilities and services, including ‘rescue and fire fighting’, as being necessary. (An attachment to ICAO Annex is intended as a guide or supplementary material to ICAO Standards and Recommended Practices.)

The fact that en route diversions have occurred in the past and will continue to occur necessitates evaluation of the facts surrounding those events and the needs they identify. ETOPS operators in the United States (as well as Europe) operating across the North Atlantic have encountered difficulties in being able to designate certain Canadian airports as ETOPS en route alternates due to the reduction of RFF service capability (Canadian airport privatization) and numerous military base closures.

History has shown that in-flight diversions occur for a variety of reasons, other than In-Flight Shutdown (IFSD) of two engine aircraft. Any aircraft conducting extended range operations could experience a critical emergency requiring the need to divert to an en route alternate airport. Thus, it is proposed by some that a regulation be established to require an en route alternate for all extended range flight operations (aircraft with 2, 3, and 4 engines) because, in such an event requiring a diversion, a simple emergency evacuation in a hostile environment (due to cold temperatures) could be deadly, or in a similar way, a mechanical event requiring a need to land could result in an unanticipated accident, such as a runway overrun and thus become catastrophic. It is further argued by some that these considerations have led to the conclusion that some level of accident mitigation systems should be required for airports designated as en route alternate airports. This accident mitigation protection is provided for at airports designated as origin and destination airports in the regulations of 14 CFR 121, and the appropriate levels of protection are specified in the airport certification regulations designated as 14 CFR 139.

14 CFR 139 specifies the level of aircraft Rescue and Fire Fighting (RFF) as a function of aircraft size. This level of protection is deemed the ‘Index’ and specifies the amount of agent for fire extinguishment and the number of vehicles to deliver the agent proportionate to the size of the largest airplane using the airport. In the international Standards of ICAO, the length and width of the aircraft fuselage determines the “RFF Category”. An allowance for reducing the index/category is provided in the event that the aircraft only uses the airport infrequently i.e., less than 700 movements in the busiest consecutive three months with the airplane in the highest category. This is termed a remission factor. Even though frequency of operations may allow a reduction of service levels by 1 Category, this reduction will no longer be allowed after January 2005 under the ICAO Standards. ICAO RFF category goes from 1 to 10. As an example, the ICAO category of RFF 4, which is nearly equivalent to Index A in 14 CFR 139, provides the minimal fire protection for aircraft comparable in size to the BAE 146 and DeHaviland Dash 8. RFF 4 provides at least 1 firefighter and 1 vehicle with the ability for immediate fire suppression or ground assistance to occupants.

Contradicting the arguments of those who support RFF at enroute alternates, some have stated that based on the last sixteen years of ETOPS operations with well over 2.5 million ETOPS flights around the world, there is no record of a single incident where a twin on an ETOPS phase of flight with a mechanical event diverted to an ETOPS alternate and the landing resulted in an unanticipated accident, such as a runway overrun and thus became catastrophic, and required the RFF services. It was further argued that the probability of an ETOPS flight diverting on the ETOPS portion of the flight, landing at an ETOPS alternate, resulting in an accident or a catastrophic situation is very remote, and need not be considered. However, some have pointed out that the fact that an event has not happened does not mean it will never happen, and industry needs to be proactive and provide a level of safety as a margin, should the situation arise.

Some have pointed out that requiring high levels of RFF protection for the enroute alternate airports would either severely limit the selection of diversion airports necessitating longer divert times, or demand the communities supporting these enroute alternate airports to increase their level of emergency service beyond that currently available. However, it can be argued that for airplanes on long diversions a pad may need to be built in so that a minimum level of RFF capability is assured at the time of landing.

Even though currently not required by 14 CFR 139, it is determined to be desirable to have some minimum level of RFF protection at the ETOPS alternates. Taking into account the various opinions expressed, the FAA established a minimum RFF of 4 for ETOPS operations below 180 minutes, and a RFF of 7 for diversion times greater than 180 minutes.

The proposed regulation allows for an off airport response time of thirty minutes, however, the required equipment must be available on-scene for the arrival of the diverting airplane and should remain for as long as their services are needed. In contrast to a destination or departure airport, the diversion airport has time to muster community emergency service assets to provide the necessary emergency response following notification of the aircraft diversion. This provision for the use of off-airport emergency services necessitates that a robust communications link must be established in order to provide sufficient time to muster the necessary RFF personnel and equipment. Further, local community emergency services support of required RFF response in providing equipment and personnel is considered prudent.

In all cases the certificate holder must ensure that the flight crews are provided current information (in plain language) concerning the RFF capability for those airports designated as alternate airports

14 CFR 121.122 *(new)*

Recommendation:

Create a new regulation 14 CFR 121.122 for supplemental operations comparable to 14 CFR 121.99(a) communications facilities on routes and at altitudes that could be used to potential alternate airports. Include in 14 CFR 121.122(b) to add a requirement for reliable voice based communication.

Rationale:

Most airplanes operate in an environment where there is usually a choice of diversion airports available within a close proximity to the route of flight. The airplane conducting ETOPS may have only one alternate within a range dictated by the endurance of a particular airframe system (e.g., cargo fire suppressant) and therefore the approved maximum diversion time for that route. Diversions undertaken in such an environment will necessarily be for emergency situations such as an inflight fire, an airplane critical system failure, or a serious passenger problem. Such diversions, precipitated by abnormal events that either demand or warrant a deviation from the normal flight profile, will bring both the airplane and its passengers and crew under some level of stress during the diversion. As such, the flight crew will have the need of increased critical communications requirements during the diversion. Consequently the regulations should require adequate communications facilities on the routes to airports that could be used during diversion over the range of altitudes flown during diversion, including altitudes flown with an engine inoperative or in the event of cabin pressurization failure, as well as demand adequate communications capabilities for the flight crew.

Communications capabilities should be able to provide the flight crew with a clear, reliable and immediate link to both the ATC and company facilities. Such capability is crucial to support long-range operations in remote areas to support problem evaluation and preclude a diversion or to protect the aircraft and it's passengers during the diversion.

Voice communication is an essential element to such a strategy, providing the necessary immediate, two-way communication that assures no increased demands on pilot workload or crew coordination. The rule is intended to require voice communication over the route, including diversion routing, where voice communication is available. Another means of communication, such as data link may be used where voice communication is not possible. SATCOM voice communication systems introduced an enhanced level of reliability and capability over earlier systems in most areas of the world. It is therefore prudent to demand the most reliable communications technology to enhance the safety of all long-range operations beyond 180 minutes from an alternate. The rule is not intended to require an operator to continually upgrade existing installations on an incremental basis, but rather to provide the evolutionary communication improvements (e.g., SATCOM versus HF) on airplanes used for ETOPS beyond 180 minutes. The systems employed in some areas of the world may require different technologies elsewhere in the world. As new technologies are introduced that significantly enhance the quality of voice based communication (e.g., SATCOM versus HF), the rule would require their employment where appropriate.

14 CFR 121.135(b)(10) *(new)*

Recommendation:

Change 14 CFR 121.135(b)(10) to require performance data to support ETOPS. [Re-number present item (10) and subsequent items.]

Rationale:

Since ETOPS are conducted under a special authorization, there is a requirement for performance data to support these operations. The flight crew and dispatchers should have available the engine inoperative and cabin depressurization cruise data used by the certificate holder to plan flights and operate under ETOPS.

14 CFR 121.135(b)(23) *(new)*

Recommendation:

Change 14 CFR 121.135(b)(23) to require a passenger recovery plan for flag and supplemental operations in the certificate holder's manual. [Refer to item (10) above and re-number present item (22) and subsequent items.)

Rationale:

It is incumbent on a carrier to ensure that a plan exists for that carrier to account for, not only operations between scheduled destinations, but contingencies when diversions occur to airports not normally served by the carrier. When a diversion occurs in an area where the carrier has a substantial operational infrastructure, (i. e. a carrier serves many destinations in Europe but is forced by operational circumstances to divert to an airport not served by the carrier but within the region) that diversion plan becomes a simple matter of describing how the carrier's assets within the region can supply immediate logistical support to the diversion aircraft. However, a carrier with an extensive route system extending over remote areas of the world has a responsibility to anticipate the possibility of a diversion within those remote regions; and devise a plan of substance that will outline how the carrier will recover the passengers, crew, and aircraft in the event of a diversion within one of these remote areas. It is intended that this plan be of sufficient detail to demonstrate that the recovery operation can be readily affected, and the basic needs of the diverted customers and crew can be provided for in the interim. The certificate holder must demonstrate that a regional plan is robust enough to handle diversion scenarios within that region.

14 CFR 121.161 *(revised)*

Recommendation:

Revise current 14 CFR 121.161 to permit operations with two-engine turbine-powered airplanes beyond 60 minutes from an adequate airport under conditions defined elsewhere in 14 CFR 121 and as authorized in the certificate holder's operations specifications.

Revise current 14 CFR 121.161 to require also that operations involving airplanes with more than two turbine engines which extend farther than 180 minutes from an adequate airport be conducted under conditions defined elsewhere in 14 CFR 121 and as authorized in the certificate holder's operations specifications.

Rationale:

14 CFR 121.161, applied originally to only twin-engine aircraft, has an extensive historical basis, which began as early as 1936. The current rule, written in early 1950s, was based on several factors that have remained constant in its application to the operation.

- The rule has always applied to all areas of operation and has not been limited to overwater operation.
- Any additional restrictions imposed or, alternatively, any deviations granted to operate in excess of the basic requirements were based on a finding by the Administrator that adequate safety would be provided in the proposed operation and current levels of safety would be maintained when all factors were considered. This finding was never limited to engine reliability alone.
- The airports used in meeting the provisions of the rule must be adequate for the airplane used (i.e., available for safe landings and takeoff with the weights authorized)
- Adequate levels of safety within the operation are to be maintained. Operations over increasingly remote areas and the possibility of increased diversion lengths have a potentially negative impact on the safety of the diversion, and thus the operation as a whole. This potential increase in risk must be mitigated by application of appropriate compensatory measures.
- When considering the impact of increasing diversion time, it must be shown that the operation can be conducted at a level of reliability which maintains an acceptable level of risk.

In June of 1985, responding to the industry's desire to take advantage of the increased reliability and capabilities of twin engine airplanes, the FAA issued AC120-42. This provided guidance on one means to obtain deviation authority from 14 CFR 121.161 and allow twin engine airplanes to operate on routes up to 120 minutes from an adequate airport after demonstration of specific levels of in-service experience and systems reliability. This Advisory Circular was amended in 1988 with the publication of AC120-42A, allowing operations of twin engine airplanes up to 180 minutes from an adequate airport. Both of these documents encompassed the following precepts:

- Reliance on a two-fold approval; type design of the airframe-engine combination (AEC) and a concurrent operator approval.
- Risk, as measured by diversion length, must be mitigated by application of regulation reflecting current best practices, which addresses the technical build standards of ETOPS airplanes and their systems and the operational environment of such operations.
- ETOPS can be managed successfully, and the level of safety can be maintained, by up to date regulations that articulate quantifiable standards of reliability and experience.

Since the advent of the original 14 CFR 121.161, extended twin operations have been governed by this process of evolving and progressive rules, which have reflected the successful and ever-increasing experience of the industry. As capable as this body of rules has been in the past, they have resided within non-regulatory documents such as the Advisory Circular 120-42A. Although these rules have acted as de facto regulations in the absence of specific rulemaking, they are only advisory in nature. It has become increasingly clear that a need existed to codify all the disparate documents into a single body of regulations and to update the existing rules to reflect all the industry improvements such progress has used as its basis. At the same time it has become evident that some of these same principles have application to all aircraft operating over remote areas of the world in extended operations. Such routes are characterized by challenging environments where divert scenarios are limited. Applying current ETOPS requirements to all such operations would sufficiently enhance the overall safety of those operations to such an extent as to justify their imposition.

The ETOPS limit for twin engine airplanes since 1988 has been 180 minutes from an adequate airport at an approved one engine inoperative cruise speed under standard conditions in still air (excluding the limited authority in the North Pacific given under the 207 Minute Policy Letter of March 2000). Service experience has shown that although limited, this authority has been satisfactory to successfully support the vast majority of the world's current aviation routes. Those areas not supported within 180-minute diversion authority tend to be routes over remote areas of the world that are uniquely challenging to the operation. The additional operational challenges of these routes are equally demanding of all airplanes, regardless of the number of engines, and include such issues as extremes in terrain and meteorology, as well as limited navigation and communications infrastructure. Support of a necessary diversion and subsequent recovery in such areas demand added training, expertise and dedication from all operators. The development of Extended Operations requirements is intended to address all these issues.

Even though for continuity with the current two engine operations the existing acronym ETOPS is retained, the ETOPS acronym has been re-defined and the concept has been expanded to also include all operations of airplanes with two or more engines, planned with their proposed flight plan at any point greater than 180 minutes from an adequate airport (at an approved one engine inoperative cruise speed under standard conditions in still air).

Airplanes divert for a variety of airplane and non-airplane-related reasons. It is prudent to expect all certificate holders to continue to flight plan to the minimum diversion authority necessary to operate efficiently on the planned route. For this reason it is reasonable to continue to demand that all ETOPS for two-engine airplanes be flight planned at 180-minute diversion authority and that such additional regulatory authority addressed in this CFR be based on specific needs in defined areas of operations. Even though airplanes with more than two engines have operated safely and successfully on long range routes in all areas of the world for many decades, it is reasonable to expect airplanes with more than two engines to designate the nearest alternate, and be flight planned at 240-minute diversion authority. The difference in application between twins and airplanes with more than two engines reflect the difference in ETOPS threshold (60 min for twins versus 180 minutes for others), the perception that there are added dimensions to twin operations, and the tacit acknowledgement of the current interpretation of the engine failure requirements of 14 CFR 121.565.

Past progress and successes achieved in twin-engine ETOPS have been due to the deliberate and limited step process of extending diversion lengths in response to improvements in type design and the operational environment. Such a regulatory review process, requiring the highest standards of operational competency and dedication from successful applicants has been instrumental in providing and protecting the tremendous success of ETOPS, and has been the catalyst for expansion in both the flexibility and scope of twin operations. Application of these concepts for all operators (twins, tris and quads) will enhance the safety of their operations and benefit the industry. The step-by-step process codified within the original AC, carried out and extended in actual ETOPS since 1984 has proven the merits of ETOPS processes and current applications. Likewise, these steps have provided both the applicant and the regulator the flexibility necessary to manage individual ETOPS authority commensurate with operational needs and defined performance criteria. That is the reason for maintaining and codifying all current twin-engine ETOPS authority within an appendix to this 14 CFR 121, as well as the additional requirements for 3 and 4 engine aircraft.

The additional, incremental steps in operational authority for twin-engine aircraft outlined in the proposed Appendix N to 14 CFR 121 are a natural progression of the processes outlined above. The justification and impetus for expansion of twin ETOPS to the new 240-minute authority is based on sufficiently increased reliability and performance of both current aircraft and operators in today's ETOPS applications. It is likewise reasonable and realistic to assume that as experience is gained and practices refined at current levels of ETOPS, that the reliability and performance of the operation will continue to improve and the foregoing premises will be validated. Therefore the new twin-engine ETOPS authority “beyond 240 minutes” is an attempt to codify such further authority. The stated requirement for 24 consecutive months of previous ETOPS operation, of which at least 12 consecutive months shall be at 240 minutes ETOPS on the airframe-engine combination for which the authority is requested, is acknowledgement that such authority has, as a prerequisite on the operator, successful application of 240-minute ETOPS.

The first authority to conduct twin-engine operations beyond 180 minutes from an enroute alternate was addressed in the 207-minute Policy Letter issued in March 2000. This increased authority was granted to address specific operational concerns in a defined geographical area of operations. The requirements placed on the operation and the measures imposed on the certificate holder to manage such an operation were consequently specific to such a limited environment. Consequently there was a significant level of confidence in its successful application. This process of limiting expanded ETOPS authority beyond 180 minutes (for twins) has been extended in the regulations and serves several purposes. The primary importance is the preclusion of an arbitrary use of diversion authority beyond that necessary to complete the operation safely and efficiently. Since it is accepted that increased diversion times potentially increase the risk of the operation, it should be a goal of all twin-engine flight planning to operate to the diversion time which provides the widest range of options in the event of a diversion while recognizing the economic benefits of a more direct route. Tying increased diversion authority to specific areas of operation accomplishes this goal while sufficiently addressing the operational needs of the industry. Likewise, this focus on specific needs and areas of operation does not add impetus to any perceived rationale for further degradation in the availability or capabilities of enroute alternates in remote areas of the world. Although the industry has no direct authority to effect the actions of sovereign nations, it is reasonable to base operations on the value of enroute alternate availability at reasonable diversion distances.

In the development of ETOPS for twin-engine aircraft it has been an accepted premise that increased diversion times increase the risk of the flight. In order to quantify such added risk, numerous risk models have been developed. In the development of AC120-42A, this risk model was a function of diversion length and propulsion system reliability or IFSD (In-flight shut down) and was “normalized” to the then established large fleet of twin civil transport turbo fan powered airplanes. The desire was to maintain an equivalent level of safety to those operations as diversion length increased. Since this risk model had a direct relationship between diversion length and risk, the basic tenet for equivalent levels of safety was a more stringent IFSD requirement for increasing diversion authority. As a consequence of this emphasis on propulsion system reliability, the industry has been driven to build airplane engines of ever increasing reliability. This impetus has given the current fleet of modern twin-engine airplanes propulsion system reliabilities that were unachievable just fifteen years ago. Current service experience for the newest generation of engines developed for the world-wide ETOPS fleet has been remarkable and a credit to both the past ETOPS processes that have driven the industry to such levels and to the engine manufacturers themselves who have designed and built them. From the IFSD targets, for two engine airplanes, of .05/1000 engine hours for 120-

minute ETOPS and .02/1000 engine hours for 180 minute ETOPS embodied in AC120-42A, this fleet currently has achieved an average in-flight shut down rate of less than approximately .01/1000 engine hours over the past few years. Such a level of engine reliability has accomplished two things.

The first is a realization that engine reliability is no longer the singular issue of focus for the safety and reliability of ETOPS or any long-range flight. As the propulsion systems have achieved ever-increasing levels of reliability, other systems and operational issues have increased in their relevance to the level of safety and have become the primary focus in order to meet required levels of reliability to insure continued safe ETOPS operations. Secondly, the IFSD level of .01/1000 engine hours itself is representative of a level of reliability that, purely from a propulsion system measure, could be supportive of an increased diversion authority for a specific airframe/engine combination (AEC) when used in most commonly accepted risk models that are asymptotic in their solutions. Such a level of IFSD placed on the industry and maintained in the operation, is the basis for increased diversion authority greater than those restrictions currently in place when all other issues are considered.

In-service data shows that the world fleet reliability of modern turbine-powered engines has improved to the extent that engine reliability becomes less of a concern than airplane systems and passenger issues as causes for diversion. Airplanes divert for a variety of airplane and non-airplane-related reasons. Engine and systems reliability have improved to such an extent that non-technical failures, i.e., failures not related to engines or airplane systems, are the major cause of all diversions. Of the airplane-related diversions on two-engine airplanes, the cause of diversions is nearly evenly split between the inflight shutdown of an engine and the failure of an airplane system such as electrical, hydraulic, pneumatic or water waste.

Because in-service data shows no difference in relative reliability between two-engine airplanes and airplanes with more than two-engines, some may reason that restrictions should not be placed on two-engine airplanes that are not currently placed on three and four-engine airplanes and that any restriction on two engine turbine powered airplanes in the current 14 CFR 121.161 should be deleted and no further restriction added. Doing so would regulate all turbine engine powered airplanes equally. Others have proposed revising the current 14 CFR 121.161 to allow two engine turbine-powered airplanes to operate beyond 60 minutes and impose similar requirement on airplanes with more than two turbine-powered engines. The guidance the FAA issued in AC 120-42A in 1985 to permit ETOPS has been instrumental in improving the overall reliability of two-engine airplanes. Continuing to require certificate holders to comply with ETOPS programs for two-engine operations farther than 60 minutes from an adequate airport is prudent.

The basic concept of ETOPS is to preclude the diversion and, if a diversion is required, to protect that diversion. Frequent diversions are precluded through rigorous design and disciplined maintenance processes, and for those few diversions that do occur, operational processes are in place to protect them. Assuming realistic circumstances, there is an en route alternate and fuel supply planned for diversion. This concept should be applied to all turbine-powered airplanes in long-range operations.

Airplanes with more than two engines have operated safely and successfully on long-range routes in all areas of the world for many decades. Some may reason that there is no need to place any additional requirement on airplanes with more than two engines. The diversion rate for all airplane-related and non-airplane related causes are comparable between two-engine airplanes and airplanes with more than two engines. Therefore, the concept of precluding and protecting the diversion has equal validity among all airplanes, regardless of the number of engines. In addition, the increased frequency of operations on routes that are far-distant from en route airports and the recent opening of routes over the Canadian and Russian far north bring additional challenges that affect the operations of all airplanes, regardless of the number of engines. Application of these ETOPS concepts for all operators of airplanes with two or more engines will enhance the safety of their operations and benefit the industry.

Because of extreme cold weather during the winter months and the limited availability of supporting services and facilities, the Polar area has been designated as an area of ETOPS applicability within which, regardless of the number of engines or an airplane's proximity to an airport, ETOPS requirements will apply to all airplanes. Support of a necessary diversion and subsequent recovery in such areas demand added training, expertise and dedication from all certificate holders.

Under 14CFR 21.4, the manufacturer is required to report IFSD events on a world wide fleet level for the airframe engine combination. The world wide fleet 12-month rolling average rates for two engine aircraft for continuing ETOPS airworthiness are:

1. A threshold rate of 0.05 per 1000 fleet engine hours for twin-engine airplanes in ETOPS for initial approval up to 120 minutes, with continuing improvement toward a rate of 0.02 per 1000 fleet engine hours
2. A rate of 0.02 per 1000 fleet engine hours for twin-engine airplanes in ETOPS up to 180 minutes, and as provided for flight by flight exception based operations up to 207 minutes maximum diversion time in the North Pacific area of operation
3. A rate of 0.01 per 1000 fleet engine hours for twin-engine airplanes in ETOPS beyond 180 minutes, except as provided for flight by flight exception based operations up to 207 minutes maximum diversion time in the North Pacific area of operation

If these rates are exceeded on the world fleet, the manufacturers must provide the mitigating modifications necessary to bring the rate within the specified value. The certificate holder should prepare a plan to incorporate those modifications provided by the manufacturer and the plan must be approved by the CHDO.

As provided by 14CFR 21.4 the FAA may issue an Airworthiness Directive (AD), if necessary, when these rates are exceeded. However, one member of the ARAC ETOPS

Working Group with specialty in 14CFR 25 believes the AD process can be cumbersome and proposes a restriction that will prompt the industry to be more proactive. As per their proposal, a new applicant would not be granted ETOPS operational approval when these rates are exceeded on the world fleet for the diversion time sought, even though the current certificate holders would be permitted to continue the operations. For example, if the world fleet average based on several airlines in US and outside US goes to .011/1000 engine hours, these airlines will be allowed to continue ETOPS operations beyond 180 minutes. However, if an airline in the US, that has been successfully operating ETOPS flights of 180 minutes or less without any problem for several years on an airframe/ engine combination (AEC), seeks an approval to operate beyond 207 minute on the same AEC, it would not be permitted to do so. Others who disagreed with this proposal have suggested that a certificate holder should not be penalized for something that is not of its making. If there is a safety or reliability issue with the airframe/engine combination, it should equally impact all operators of the fleet. Some consider the proposal discriminatory. This proposal could even have an unintended consequence of letting a group of airlines restrict a new US entrant in a market.

These IFSD numbers were based on risk models. In support of the FAA tasking, the ARAC reviewed various risk models. The objective of the risk model was to determine the IFSD rate requirement associated with longer diversion times that would provide the comparable level of risk to the180-minute diversion of an airplane with two engines with an IFSD rate of .02/1000 engine hours. Even at the extreme diversion time of 10 hours, all the risk models examined showed that an IFSD level of .01/1000 engine hours would provide the same risk as .02/1000 engine hours at 180 minutes (3 hours) diversion. In the last few years the 12-month rolling average IFSD rates for most airframe engine combinations used on ETOPS have averaged less than .01/1000 engine hours. Even though the risk model concluded that only as diversion allowances approached an extreme, unrealistic 10 hours would an.01/1000 engine hours IFSD rate be required, the ARAC Working group decided to require a 12-month rolling average IFSD rate of .01/1000 engine hours on the world fleet for all operations beyond 207 minutes which would include even the 240 minutes on a flight by flight exception basis.

All operators of airplanes with two or more engines operating on ETOPS routes must comply with all the operational and process requirements specified in the ETOPS regulations in 14CFR 121 as of the effective date of these regulations. However, it is not the intent of the FAA to require certificate holders who, at the time of the effective date of these ETOPS rules have the authority to operate on specific ETOPS routes, or routes that under the new definition are classified as ETOPS routes, to re-apply for the specific route authority.

14 CFR 121.368 *(new)*

Recommendation:

Include ETOPS maintenance requirements

Rationale:

The whole premise of ETOPS has been to preclude a diversion and, if it were to occur, to have programs in place that protect the operation of the diversion. Under this concept, propulsion systems are designed and tested to assure the absence of an unacceptable level of inflight shutdown in the worldwide fleet. Similarly, other key airplane systems are also designed and tested for enhanced reliability. ETOPS maintenance practices reduce diversions through disciplined procedures like engine condition monitoring, oil consumption monitoring, the aggressive resolution of reliability issues, and procedures that avoid human error during maintenance of airplane systems and engines.

Before flying ETOPS, a certificate holder must develop an ETOPS maintenance program that complements its basic maintenance program and provides necessary training as appropriate. The ETOPS maintenance program requires the certificate holder to ensure that its fleet (airframe-engine combination) complies with the ETOPS configuration requirements as established during the type design approval for that airframe/engine combination, plus any additional airworthiness directives that may impact reliable ETOPS operation. Certificate holders are also required to develop event-oriented reliability programs, and monitor airplane status through engine condition and oil consumption monitoring of all the airplanes in the ETOPS fleet. Should an inflight engine shutdown occur, the certificate holder must immediately investigate and report the cause of the shutdown.

Propulsion System Monitoring is vital to ensuring the twin engine airplane ETOPS certificate holder incorporates procedures to maintain the operator's ETOPS to a standard commensurate with the fleet's operation. The accomplishment of propulsion system monitoring at the operator level has been accomplished via the guidance of AC120-42A which defined a specific IFSD rate for 180 minute ETOPS. The AC stated in part:

> *"Firm criteria should be established as to what action is to be taken when adverse trends in propulsion system conditions are detected. When the propulsion system IFSD (computed on a 12-month rolling average) exceeds .05/1000 engine hours for a 120-minute operation, or exceeds .03/1000 engine hours for a 180-minute operation, an immediate evaluation should be accomplished by the operator and certificate- holding district office. . ."* (AC120-42A, Appendix 4, Paragraph 8)

In many respects, this approach has worked well in assuring that the ETOPS fleet as a whole has remained safe and that the standard in engine reliability has remained consistently high. However, there have been shortcomings with the approach that must be considered in codifying the appropriate method of propulsion system monitoring:

> **1) Foreign Regulator Misapplication**.
> Despite disclaimers that operational restrictions should not be based solely on comparison to numerical IFSD rate limits, experience has shown that this often takes place around the world; this is often due to the difficulty of translating the nuances of fleet management from English. IFSD rates are very easy to calculate and have the potential to become a very visible sole measure of the reliability of

the propulsion system. The reliance on the point estimate of IFSD rate means a more in depth analysis can be avoided. The imposition of an operational restriction is seemingly easier to justify. The rule and AC correctly direct the Airline, Airframe Manufacturer, Engine Manufacturer and Regulator to determine the cause and corrective action for each and every IFSD event without strict adherence to a point estimate IFSD rate for a potentially small subset of the world fleet.

2) Statistical Confidence.

IFSD rate calculation, whether based on cumulative experience or a moving average, (12 month for example), is necessarily a point estimate of the inherent reliability for the equipment. The use of point estimates is inherently misleading. As shown conceptually in Figure 1, the confidence band or uncertainty is very large for small sample sizes, which are typical of small fleets and entry into service experience. Even with significant service experience, upper and lower confidence limits exist around the point estimate. The bands shown in Figure 1 are typical of bands based on approximately a 50% and 90% level of confidence. For example, for the larger sample size shown, if the calculated value is as shown, we can only be 50% confident that the true IFSD rate of the entire population is between the upper and lower limit of the red lines. For a 90% level of confidence, the width of the band or uncertainty increases.

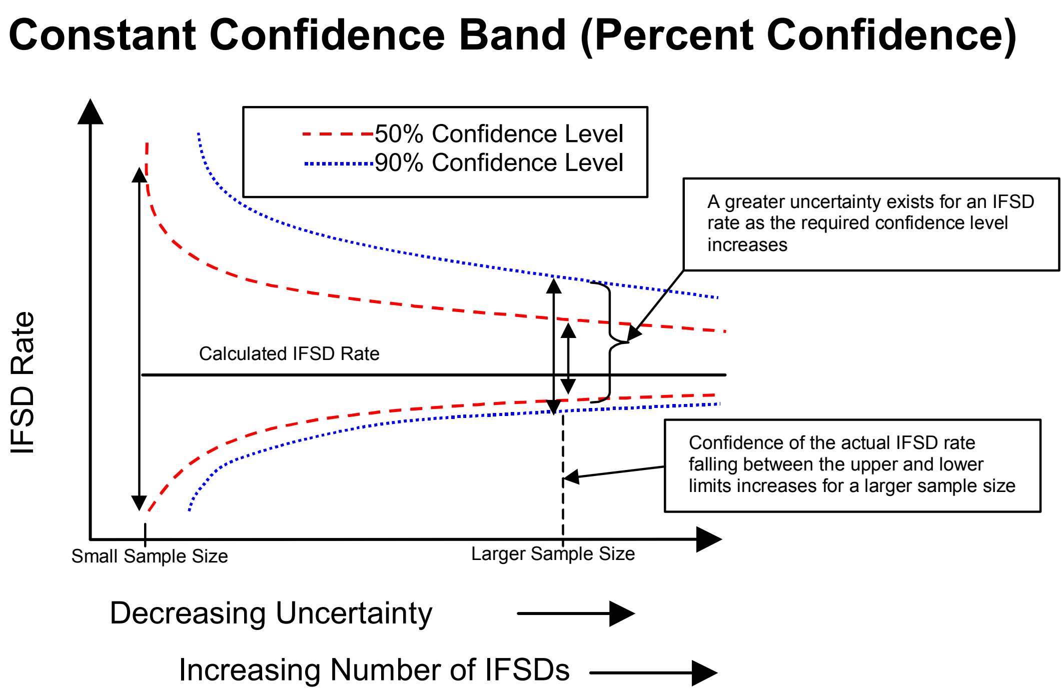

Figure 1

The level of confidence in a point estimate can be viewed in another way. Suppose the initial in-service experience produces a relatively stable IFSD rate around the nominal value. If a constant band were chosen, for example +/- 20% of the requirement, (0.004/1000 for a nominal 0.02 rate requirement or 0.016 to 0.024), the confidence level associated with the early experience or a small sample size, is only 20 to 40 %. This is shown conceptually in figure 2. Managing solely by the point estimate of IFSD rate can give an inappropriate sense of risk when exceeding it.

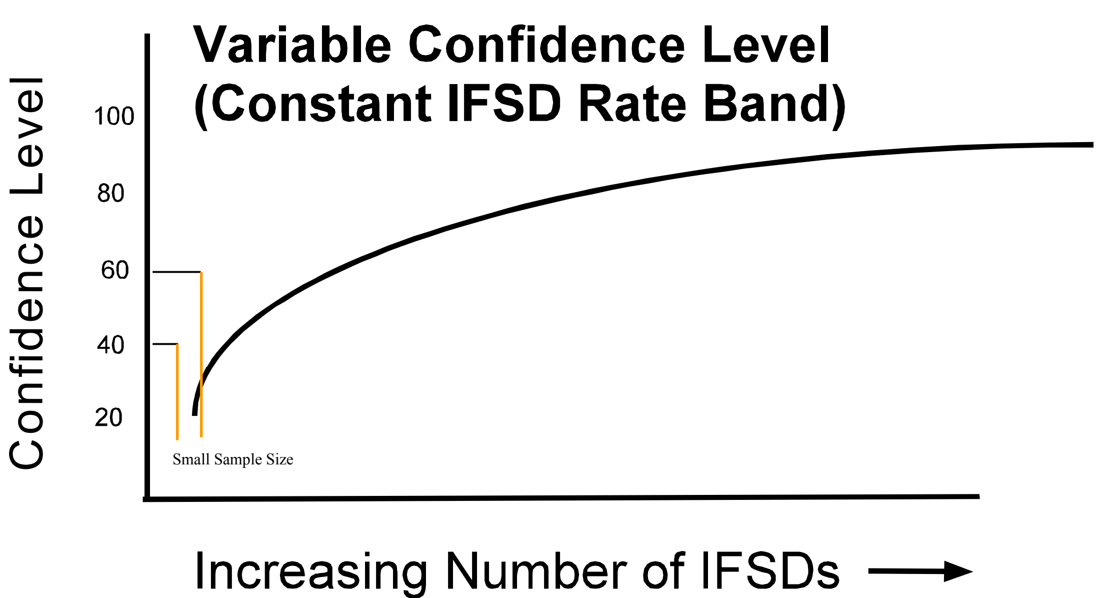

Figure 2

3) Producer's Risk, Consumer's Risk
The management of IFSD rate acceptability can be notionally compared to established failure testing techniques as identified in MIL STDs and MIL HDBKs. MIL-HDBK-781, for example, contains a number of test plans, which allow a choice to be made between the statistical risks involved, (i.e. the risk of rejecting equipment with true reliability higher than specified or of accepting an equipment with true reliability lower than specified) and the ratio of minimum acceptable to target reliability. The risk of good equipment being rejected is called the producer's risk. The risk of bad equipment being accepted is called the consumer's risk.

As applied to IFSD rate management, Airline and Airplane/Engine Manufacturers risk is comparable to the producer's risk, and Regulator and public risk is comparable to consumer's risk. All elements of these test plans are not necessary or applicable to grasp the notional application of this technique. Specifically, an "Accept" line does not apply, as monitoring and tracking will continue for the life of the fleet, and the ratio of minimum acceptable to target reliability is a complexity not needed. The test plans are based upon the assumption of a constant failure rate but this concept is still appropriate, with modification, for equipment that exhibits a changing failure rate. This concept is depicted in figure 3.

As applied to IFSD rate management: "Number of Failures" is number of IFSDs, "Test Time" is hours accumulated in service experience and "Continue Testing" is simply a region where the calculated IFSD rate tracks close to the requirement, perhaps a little above or below, but in which range "drastic" action (operational restrictions or revoking of ETOPS/LROPS approval) is not required This protects against the risk of "rejecting good equipment".

Shown in the concept is a band in which both the producer and consumer are protected at specified level of risk. As long as the point estimate remains below the Reject Line, the consumer (regulator) is protected.

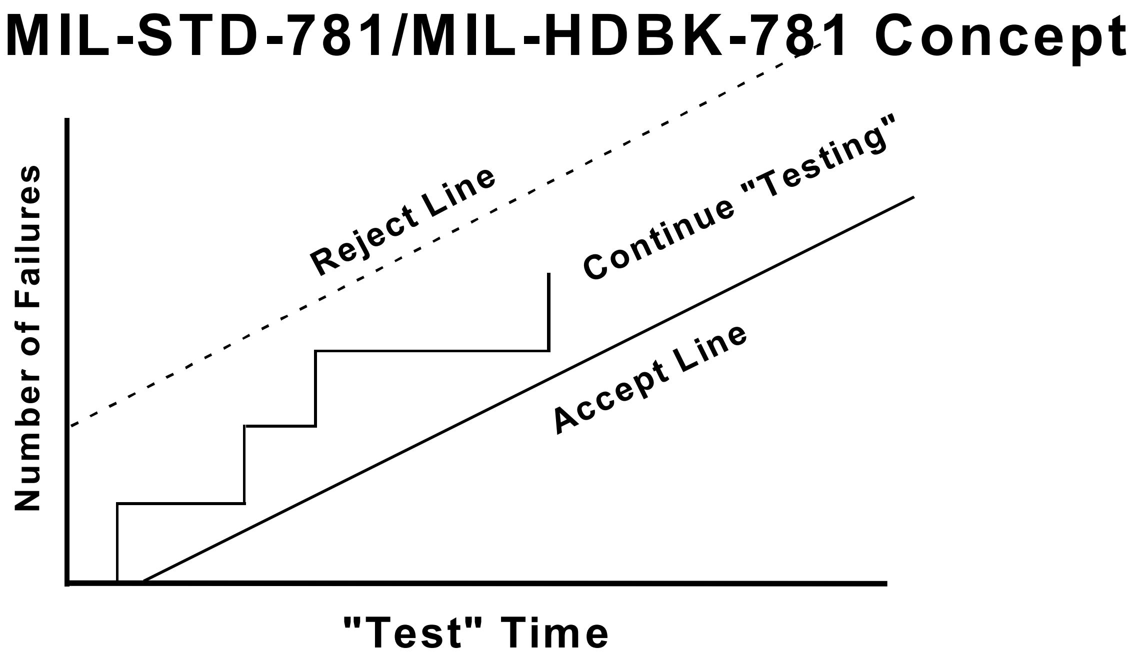

Figure 3

Regulatory Application

Despite the challenges of the use of a point estimate in determining individual airline suitability for ETOPS, it is acknowledged that the regulatory agencies require a simple method for determining when to engage with an operator on propulsion system reliability. The above concepts provide the rationale as to why a simple examination of IFSD rate at an operator level is inadequate to determine propulsion system health and that a deeper understanding of every event in an airline fleet is required rather than a cursory examination of a point estimate. Typical "flags" for a regulator should include a consistently high IFSD rate with respect to the world fleet rate, a step increase in the number of events in a short period of time, multiple maintenance or operational events, and non-IFSD events that are attributable to maintenance or operational errors.

The rule and advisory circular material for the proposed 14 CFR 121.633(j) must include the guidance necessary to avoid over-emphasis on either "producer" or "consumer risk as identified above.

In order to provide the regulatory agencies with the desired "trigger" level of IFSD rate for the investigation of common cause effects or systemic errors, the methodology derived in AC120-42A is accepted in the new rule, i.e., operator rates should be within +. 01/1000 the world fleet target rate specified in 14 CFR 21.4, or regulatory investigation is initiated. It is not the intent of the ARAC committee to create a situation where the regulators can oversimplify their oversight responsibilities by creating these numerical targets; in fact, the burden to investigate each IFSD cause will require the regulatory agencies to understand to a higher level the situation at any given airline.

14 CFR 121.415(a)(4) *(new)*

Recommendation:

Add new regulation to require training for crewmembers and dispatchers in their roles and responsibilities in the certificate holder's passenger recovery plan be included in the certificate holder's approved training program.

Rationale:

Crewmember and dispatcher involvement in seeing to the welfare of passengers following a diversion often is an important factor in the success of post diversion passenger handling. With ETOPS and the possibility of diversion to a remote foreign airport with reduced services and facilities available for passenger welfare, it is increasingly important that the certificate holder have a passenger recovery plan and that crew members and dispatchers understand their role in that plan. Current regulations do not require training for crewmembers or dispatchers in their role in a certificate holder's passenger recovery plan. The role of the crewmembers and dispatchers must be defined and the training program tailored around those defined roles.

14 CFR 121.565(a) *(revised)*

Recommendation:

Change the wording of 14 CFR 121.565(a) from "…whenever the rotation of an engine is stopped to prevent possible damage," to "… whenever an engine is shut down to prevent possible damage."

Rationale:

A minor revision to 14 CFR 121.565(a) is recommended to delete the reference to stopping the rotation of an engine, which applies only to propeller driven airplanes, and adding reference to engine shutdown, which applies to all airplane engines.

14 CFR 121.624 *(new)*

Recommendation:

Add a regulation, which specifies the dispatch requirements for an ETOPS alternate, and the requirements for a valid ETOPS alternate after takeoff.

Rationale:

One of the distinguishing features of ETOPS operations involving twin engine aircraft that is being expanded to include ETOPS operations of aircraft with more than two engines is the concept of an en route alternate airport being available to which an airplane can divert after experiencing an event which requires a diversion. Whereas most airplanes operate in an environment where there is usually a choice of diversion airports available within a close proximity to the route of flight, the airplane conducting ETOPS may have only one alternate within a range dictated by the endurance of a particular airframe system (e.g., cargo fire suppressant) and therefore the approved maximum diversion time for that route. Therefore, it is important that any airport designated as an ETOPS alternate has the capabilities, services and facilities to safely support the airplane and its passengers and crew during the diversion.

The weather conditions at the time of arrival should provide a high assurance that adequate visual references are available upon arrival at decision height (DH) or minimum descent altitude (MDA), and the surface wind conditions and corresponding runway surface conditions must be within acceptable limits to permit the approach and landing to be safely completed with an engine and/or systems inoperative.

At dispatch, an enroute alternate must meet the alternate weather requirements specified in the certificate holder's operations specifications. Due to the natural variability of weather conditions with time, as well as the need to determine the suitability of a particular enroute alternate prior to departure, such requirements are higher than the weather minimums required to initiate an instrument approach. This is necessary to assure that the instrument approach can be conducted safely if the flight must divert to an alternate airport. Additionally, since the visual reference necessary to safely complete an approach and landing is determined, among other things, by the accuracy with which the airplane can be controlled along the approach path by reference to instruments and the accuracy of the ground-based instrument aids, as well as the tasks the pilot is required to accomplish to maneuver the airplane so as to complete the landing, the weather minima for non-precision approaches are generally higher than for precision approaches.

A regulatory requirement for an ETOPS alternate meets a prudent planning requirement for an en route diversion alternative for all long range aircraft in the event an engine failure, an airplane system failure or a serious passenger problem. A new regulation is required to specify the dispatch and en route requirements for ETOPS alternates. In addition, past experience in ETOPS operations of twin engine aircraft with en route diversions for reasons other than engine failure justify the imposition of a requirement to designate en route alternate for all long range operations with airplanes with two or more engines. The additional operational challenges of these routes are equally demanding of all airplanes, regardless of the number of engines, and include such issues as extremes in terrain and meteorology, as well as limited navigation and communications infrastructure.

ETOPS alternate weather minima are and should continue to be derived from the same standard criteria used to determine the weather minima for all alternates. Those criteria are contained in the standard air carrier operations specifications paragraph C55. The ETOPS alternate weather minima standards provided in the recommended Advisory Circular 120-XX, "Extended Operations (ETOPS)" contain minor changes to the currently used criteria in operations specifications paragraph C55 for the purpose of clarification, technological advancements and standardization of its application. Since operations specifications alternate weather minima standards apply to all alternates, the ETOPS Working Group further recommends a concomitant FAA revision of paragraph C55 as stated in the recommended Advisory Circular. Once the standard paragraph is amended, operators could then apply for the revision to their individual operations specifications.

14 CFR 121.625 *(revised)*

Recommendation:

Revise 14 CFR 121.625 to clarify the intent of this regulation as being applicable to destination and takeoff alternates only and not to ETOPS alternates requirements which are the subject of proposed new regulation, 14 CFR 121.624 ETOPS Alternates.

Rationale:

This regulation, as the title confirms, is applicable to destination and takeoff alternates. The dispatch and en route requirements of proposed 14 CFR 121.624 ETOPS alternates are different and serve a different purpose. Thus, a clarification of 14 CFR 121.625 is prudent.

14 CFR 121.631 *(revised)*

Recommendation:

Revise 14 CFR 121.631 to specify weather requirements for ETOPS alternates while a flight is en route and the availability of the option to amend the dispatch / flight release to add another ETOPS alternate if a required ETOPS alternate becomes unavailable. In addition, specify the actions required of the pilot in command and, in flag operations, the dispatcher in the event a designated ETOPS alternate becomes unavailable and no other airport satisfying ETOPS alternate requirements is available.

Rationale:

14 CFR 121.631 should be modified to address weather conditions required at designated ETOPS alternates while a flight is en route. This regulation is consistent with the standards of AC 120-42A.

The proposed regulation also specifies the action required of the pilot in command and, in the case of flag operations, the dispatcher, in the event a required, designated alternate becomes unavailable and no other qualifying airport is available. In that event, the flight may not continue as an ETOPS flight unless another track that qualifies is available. The FAA recognizes that this may sometimes cause disruptions in scheduled operations and anticipates that carriers will adjust the enroute alternate weather minimums upward on routes on which this becomes more than a very infrequent problem. This situation is not addressed in current regulations. The advisory circular governing these operations has had the practical effect of being a regulation since operational approvals are not given without assurance that the advisory circular will be followed in all its particulars. Regulatory guidance should be provided as proposed in 14 CFR 121.631.

14 CFR 121.633 *(new)*

Recommendation:

Add new regulation 14 CFR 121.633 to require that planned ETOPS diversion times not exceed the time limit specified in the Airplane Flight Manual (AFM) for the airplane's most time-limited system minus 15 minutes. For airplanes with more than two engines and type design certificated before the effective date of this regulation, the effective date for compliance with 14 CFR 121.633(b) should not be later than six years following the date on which this rule becomes effective.

Rationale:

All airplanes operated under 14 CFR 121 are required to comply with 14 CFR 121.161 which imposes special requirements in order for a two-engine airplane to operate over a route that contains a point further than 60 minutes flying time from an adequate airport and for an airplane with more than two engines to operate over a route that contains a point farther than 180 minutes flying time from an adequate airport at normal one-engine inoperative cruise speed in still air.

AC 120-42 in 1985 and AC120.42A in 1988 recognized the increasing reliability of turbojet engines and helped to establish type design and operational practices for safe and reliable long-range operations with two-engine airplanes. The technology and reliability of twin engine airplanes continued to improve, due, in a large measure, to the long range operations typically associated with 3-4 engine airplanes. At the same time this technology brought twins to the arena of long range operations, the infrastructure to support such operations was changing. Political and funding priorities forced the closure or reduction in basic services of a number of airports, both military and civilian, in remote areas that historically had been used as diversion airports for routes over oceanic and/or desolate land areas. The increasing use of Polar flights, while creating economic benefits, have brought new challenges to the operation. This reduction in operational infrastructure began to significantly impact the viability of all long-range twin-engine operations under current regulations and likewise began to erode the basic safety net that long-range operations in three and four engine aircraft had relied upon. Due to these pressures and to the increasing commonality of all long-range operations, the data began to show that ETOPS requirements and processes are generally applicable to all long-range operations including those by three and four engine airplanes and would improve the safety and viability of all long range operations. The reliability and system architecture of modern twin engine airplanes have begun to meet or exceed the capabilities of current 3-4 engine long range airplanes and it was believed that all long range airplanes, regardless of the number of engines, needed a viable diversion airport in the case of onboard fire, medical emergency or catastrophic decompression. This is especially important considering that routes over remote areas of the world are uniquely challenging to the operation. The additional operational challenges of these routes are equally demanding of all airplanes, regardless of the number of engines, and include such issues as extremes in terrain and meteorology, as well as limited navigation and communications infrastructure. Ensuring availability of en route alternate airports, adequate fire fighting coverage at these airports, and fuel planning to account for depressurization are sound operational practices for all airplanes including three and four engine airplanes. Likewise, all airplane time critical systems should account for the maximum allowable diversion and worst-case scenarios. To address these issues, a reasonable approach was to demand that many of the ETOPS requirements for twin engine aircraft operations, based on sound safety principals and successfully proven over many years of operations, should be applied to all long-range operations. As a result, 14 CFR 121.633 has been developed to codify the operating practices with regard to diversion time and time critical systems that applied to the operations of twin engine aircraft into regulations and to expand those regulations to include airplanes with more than two engines in long range operations.

The whole premise of ETOPS has been to preclude a diversion and, if it were to occur, to have programs in place that protect the diversion. Under this concept, propulsion systems are designed and tested to assure an acceptable level of in-flight shutdown; other airplane systems are designed and tested to ensure their reliability. However, despite the best design/testing, and maintenance practices, situations have occurred which required an airplane to divert. In-service data has also shown that all airplanes, regardless of the number of engines, divert from time to time for various causes. Airplanes with more than two engines currently are operated in areas where there are a limited number of enroute airports, where the support infrastructure is marginal or with challenging weather conditions. All such operations should adopt the same ‘preclude and protect’ concept.

Under the ‘preclude and protect’ concept, various failure scenarios need to be considered. For example, during the design of the airplane, time limited systems such as cargo compartment fire suppression/containment capability are considered. The fuel planning process accounts for the possibility of decompression and/or the failure of an engine with considerations for icing.

If airplanes with more than two engines plan to operate in areas where en route airports are farther than 180 minutes or in north polar areas where weather conditions can be challenging at certain times of the year, these operations are required to meet the standards to ensure that all efforts are made to preclude a diversion and, if a diversion were to occur, procedures are in place to protect that diversion. This would include systems capability to protect the aircraft and its occupants during the entire length of the diversion. As such, for ETOPS operations less than 180 minutes the one engine inoperative cruise speed maximum diversion time in still air under standard temperature conditions to each ETOPS alternate may not exceed the time specified in the Airplane Flight Manual (AFM) for the airplane’s most time-limited system minus 15 minutes (for approach and landing).

In ETOPS operations wind becomes an increasingly significant factor with increasing diversion times and should be considered in ETOPS operations beyond 180 minutes to assure that AFM system time limits are not exceeded. For example, while diverting with an engine inoperative, it is essential to ensure that there is sufficient amount of oil in the tank for continuous operation of the remaining engines at Maximum Continuous Thrust for the actual duration of divert. As a result, for ETOPS operations with approved diversion times greater than 180 minutes the one engine inoperative cruise speed (approved) maximum diversion time, taking forecast wind and temperature into account, to each ETOPS alternate may not exceed the time specified in the airplane flight manual for the airplane’s most time-limited system minus 15 minutes (for approach and landing). However, there are some other time limited systems like cargo fire suppression, where the use of cargo fire suppression may not have as much relevance to the one engine inoperative diversion time. Data was presented that showed the likelihood of an engine failure at the critical point followed by cargo fire to be extremely remote. Hence for ETOPS beyond 180 minutes, cargo fire suppression requirement shall be based on covering the diversion distance authorized (maximum diversion time authorized at the approved one engine inoperative speed) at the all engine operating speed. It has already been stated that for ETOPS operations beyond 180 minutes wind becomes an increasingly significant factor with increasing diversion times and should be considered. Therefore this rule requires that for ETOPS beyond 180 minutes, cargo fire suppression time required be based on the airplane operating at all engine operating speed with actual wind. For ETOPS at or below 180 min, there is precedence in AC 120-42, to require cargo fire suppression for the maximum diversion time based on one engine inoperative

speed. This precedence shall be retained. The cargo fire suppression time in all cases shall also include 15 min allowance for holding, approach and landing.
During development of this regulation much discussion took place regarding aircraft utilized in long haul operations that routinely operated with diversion times that exceeded certain aircraft system capabilities. While this regulation will require the modification of those aircraft, those modifications should be done within a time frame that would not place an undue burden on the operators. It is felt that these modifications can be easily accomplished within the aircrafts routine maintenance, "D check", cycle. A number of US operators were queried and the time frame of 6 years from the effective date of this regulation was determined to be the most practical time frame to require the modification of these aircraft.

14 CFR 121.646 (*new)*

Recommendation:

Add a new rule, 14 CFR 121.646, to specify the fuel supply required following depressurization (all airplanes).

Rationale:

Current regulations contain no requirement for a fuel supply sufficient to reach an en route diversion airport.
ICAO Annex 6, Part I, section 4.3.6.4(d) requires consideration of additional fuel in the event of loss of pressurization. JAR OPS1 complies with this ICAO requirement. Although 14 CFR 121.329 requires descent following cabin depressurization "to an altitude that will allow successful termination of the flight," there is no explicit requirement in the current 14 CFR 121 for a fuel supply in the event of cabin depressurization to assure a safe landing. It should be noted that, as a matter of policy, several U.S. operators provide fuel for cabin depressurization because of the 14 CFR 121.329 implied requirement.

The AC 120-42 published in 1985 and amended in 1988, considered the fuel supply required at the most critical point in the ETOPS area of operation in the event of the cabin depressurization, and also considered the possibility of a simultaneous failure of an engine. As the probability of depressurization is comparable between airplanes with two or more than two engines, the proposed 14 CFR 121.646 retains the AC conditions for fuel supply to an ETOPS alternate in the event of cabin depressurization for all ETOPS operations.

For airplanes with more than two engines the 14 CFR 121.329 implied fuel supply requirement becomes a regulatory requirement. 14 CFR 121.646(a) applies to operations more than 90 minutes (with all engines operating at cruising power) and less than 180 minutes (at the approved one engine inoperative cruise speed) from an adequate airport, while the requirements in 14 CFR 121.646(b) apply for operations greater than 180 minutes (at the approved one engine inoperative cruise speed) from an adequate airport.

Further, the AC required consideration of fuel for icing at the cabin depressurization cruise altitude and consideration of errors in wind forecasting.

Studies done by the Atmospheric Environment Service of Canada with the assistance of airplane manufacturers under the second Canadian Atlantic Storms Program (CASP II) confirm that the probability of a continuous or repetitive significant icing encounter is very small on a long flight segment. The airspeeds associated with cruise at cabin depressurization altitude are not conducive to ice build-up. Moreover, pilots can avoid icing with minor changes in altitude or by changing the cruise speed, either of which can have a large effect on ice accretion. Based on the CASP II study, considering the probability of encountering depressurization at the critical point and icing on the same flight, an argument was made that fuel for icing in addition to fuel for depressurization is not deemed necessary. However, as a conservative measure, 14 CFR 121.646 requires fuel to compensate for the greater of the effect of airframe icing (including the fuel used by engine and wing anti-ice during this period) during 10 percent of the time for which icing is forecast, or a combination of fuel for engine anti-ice, and for some models of airplanes based on their characteristics and the manufacturer's recommended procedures fuel for wing anti-ice for the time during which icing is forecast.

Based on the weather forecasting techniques of the early 1980s, the AC required a five percent fuel pad to account for wind forecast errors. However, winds aloft forecasting has improved dramatically in the last twenty years as a result of the following:

- The sophistication of wind forecast models have experienced a quantum improvement. These models provide forecasts based on a wider range of inputs and more accurate extrapolation throughout the altitude profile.

- Wind forecasting responsibilities have been assigned to computers with vastly increased capacity, capability, and speed.

- The flow of input data has significantly increased; largely as a result of systems that automatically downlink weather information at much more frequent intervals. Additionally, weather is measured on a worldwide grid of collection points. This grid has nearly four times the collection points compared to the grid used previously.

- Information gleaned from satellite downlinks and satellite depictions of air mass movement are added to the data stream, not only to fine tune forecasting at frequently flown altitudes, but also to provide more accurate forecasts at lower altitudes (10,000 to 15,000 feet) where the decompression profiles are flown.

This information is collected, analyzed, and distributed worldwide by the World Area Forecast System (WAFS). This centralized distribution of weather information provides for a consistent level of accuracy that can eliminate the assignment of arbitrary penalties, provided that individual airlines subscribe to the service and make use of this level of information.

Therefore, given the documented improvements in forecasting accuracy when using WAFS, a more accurate means of determining the fuel used during a decompression profile involves adding a pad to the actual forecast winds in making the fuel calculation rather than adding an arbitrary fuel penalty. The addition of a five- percent wind error pad provides an accurate case-by-case adjustment as compared with a five- percent fuel penalty, while preserving the necessary level of safety. However, if a certificate holder elects not to use such accurate winds in the computation of decompression fuel, then it will be required to continue applying the five percent fuel pad to account for wind forecast errors.

14 CFR 121.646 requires accounting for any airplane performance degradation on the fuel requirement. In addition, if APU is a required power source, then its fuel consumption also must be accounted for.

14 CFR 121.687 *(new)*

Recommendation:

Add 14 CFR 121.687(a)(6) to add the ETOPS approval basis (e.g., 120 minute or 180 minute ETOPS) under which the flight was dispatched to the required content of the dispatch release of each ETOPS flight.

Rationale:

Proposed 14 CFR 121.687(a)(6) assures that the pilot in command of an ETOPS flight is notified as to the time basis, (e.g., 120 minute or 180 minute ETOPS) including the Minimum Equipment List (MEL) limitations, under which the flight is dispatched.

14 CFR 121.689 *(new)*

Recommendation:

Add 14 CFR 121.689(a)(8) to add the ETOPS time basis under which the flight was released to the required content of the flight release of each ETOPS flight.

Rationale:

Proposed 14 CFR 121.689(a)(8) assures that the pilot in command of an ETOPS flight is aware of the limitations, including the Minimum Equipment List (MEL) limitations, under which the flight is released.

14 CFR 135

Recommendation:

Add sections 135.98: Polar Operations, 135.364 Multi-Engine Airplane Limitations: Maximum Distance From An Airport, and 135.345 Pilots: Initial, Transition, and Upgrade Ground Training paragraphs (a)(9) ETOPS, if applicable and (a)(10) Passenger Recovery for ETOPS, if applicable.

Rationale:

The intent of the proposed rule for operations under 14 CFR Part 135 is to first ensure that airplanes that operate over areas where airports are sparse are designed, operated and maintained in such a manner that en-route diversions are uncommon. And, if such a diversion does occur, that the airplane can safely land at an airport. These goals are identical to those outlined for operations conducted in accordance with 14 CFR Part 121.

Background:

Long-Range Flights and Part 135.

In 1998, FAA introduced 14 CFR Part 119, which modified the types of operations permitted in accordance with 14 CFR Part 135. "On-demand" operation of an airplane for compensation or hire is permitted under the provisions of 14 CFR Part 135 provided the airplane:

- has a passenger-seat configuration of 30 seats or less, excluding each crewmember seat; and,
- has a maximum payload capacity of 7,500 pounds or less.

Although certain operations (including infrequent scheduled service) of airplane with a maximum passenger seat configuration of less than 9 seats, excluding crewmember seats, and a maximum payload capacity of 7,500 pounds or less are also authorized under 14 CFR Part 135, these airplane (including rotorcraft) do not typically have the fuel capacity to allow long-range operations. There is no intent to allow operations beyond 180-minutes by these types of airplane under the proposed ETOPS rule, even if they were designed or modified with additional fuel tanks that would allow longer range flights.

ICAO Requirements. FAA is signatory to the convention on International Civil Aviation. Paragraph 4.7.1 of Annex 6, Part I (International Commercial Air Transport – Aeroplanes) of International Standards and Recommended Practices published by the International Civil Aviation Organization (ICAO), states:

> *"Unless the operation has been specifically approved by the State of the Operator, an aeroplane with two turbine power-units shall not, except as provided in 4.7.4, be operated on a route where the flight time at single engine cruise speed to an adequate en-route alternate aerodrome exceeds a threshold time established for such operations by that State."*

Paragraph 1.2 in Attachment E to ICAO Annex 6, "Extended Range Operations by Aeroplanes with Two Turbine Power-Units", states:

> *"… Pending the acquisition of additional data for such operations by twin-engined commercial transport aeroplanes and taking into account the level of safety intended by 4.7.2, it is suggested that the threshold time be 60 minutes."* (Emphasis added.)

It is clear that when proposing its Standards and Recommended Practices (SARPS) for long-range operations, ICAO intended that each State should have significant flexibility in adopting appropriate thresholds limiting long-range flights based on the demonstrated safety of those operations, and that ICAO did not intend to require that existing commercial operations with satisfactory safety records be halted.

FAA recognizes, however, that it will not fully comply with ICAO SARPS until it specifies a maximum distance from an airport for all commercial operations, including those conducted in accordance with 14 CFR Part 135.

Safety. A 2000 review of airplane accidents, performed by Robert Breiling for the National Business Aviation Association, revealed that during the period 1964 to 1999 there has never been an accident associated with long-range operation of an twin-engined airplane operating in accordance with 14 CFR Part 135. As most of these airplanes had a range that would limit operations to no more than 180 minutes from an airport, and FAA never found sufficient safety justification for imposing additional regulations on these operations, FAA did not publish a rule establishing the maximum distance from an airport for flights operated in accordance with 14 CFR Part 135.

In 1996, manufacturers began delivering a new generation of twin-engine, turbine powered airplane with very long-range capabilities (up to 6,500 NM). Like other airplanes of similar size, they were used for on-demand operations in accordance with 14 CFR Part 135.

Existing FAA Policy. In 1996, the European Joint Aviation Authorities (JAA) proposed a regulation that would have limited commercial operations of small airplanes to less than 120 minutes from an aerodrome, unless specifically approved by the State authority.

When responding to this JAA Notice of Proposed Amendment, FAA first expressed its policy of a 180-minute threshold for operations conducted in accordance with 14 CFR Part 135. FAA stated:

"… we have a philosophy difference in regulatory requirements for air carrier operations. The FAA system, albeit complex, recognizes several categories of air carrier operations as defined by FAR Part 119. Categories are based on scope and frequency of operation, size of equipment, and geographical area of operation." "…operations are conducted in accordance with FAR Part 135, which specifies engine out performance criteria in lieu of a threshold." … "Although we have appreciation for your (JAA) system, we see difficulties with a structure that imposes identical operational requirements on an on-demand (charter) AOC holder with one light twin engine airplane, compared to a mega size AOC holder operating a large fleet on international routes."

"Our regulation (FAR Part 135) concerning the operation of business jets in on-demand type operations on extended range flights does not require special authorization. We have though, by de facto, maintained a policy over the years, which when stated is indicative of a non-ETOPS threshold of 180 minutes. We have for many years allowed operations in the North Atlantic to Europe and in the Pacific with operations to Hawaii. Establishing a written 180-minute threshold policy allows these operations to continue without new or additional requirements. … Stating such a policy certainly reflects and recognizes the 30 plus years experience and safety record gained by the industry, and supports the continued operation of business jets on extended range operations."

Introduction:

The FAA tasked ARAC to "develop standardized requirements for extended range operations for all airplanes, regardless of the number of engines, including all turbojet and turbopropeller commercial twin-engine airplanes (business jets), excluding reciprocating engine powered commercial airplanes. This effort should establish criteria for diversion times up to 180 minutes that is consistent with existing ETOPS policy and procedures. It should also develop criteria for diversion times beyond 180 minutes that is consistent with the ETOPS criteria developed by the working group". Whenever feasible, the ETOPS ARAC has prescribed the same operational procedures for long range operations beyond 180 minutes under 14 CFR Part 135 as those found under 14 CFR Part 121.

While the ARAC attempted to parallel as closely as possible the requirements for 121 and 135 ETOPS, some significant differences exist between the two regulatory environments. First, the presence of adequate crash, fire and rescue equipment is an important consideration for 14 CFR Part 121 operations, which may operate many times per year to a single location with a relatively large number of passengers. Although adequate RFF service is highly desirable for any long range operations, it is not feasible to require the presence of crash, fire and rescue equipment at an airport before authorizing an on-demand operation that may operate only once a year with very few passengers. Therefore, no such requirement exists in 14 CFR Part 135. Second, due to the reliability of powerplants in small fleets of airplanes, combined with lower annual cycles and lower total fleet sizes, the use of an in flight shutdown rate (IFSD) to determine corrective maintenance action for ETOPS is unsuitable. Rather, 135 ETOPS operators would work with the aircraft and engine manufacturer to aggressively identify the cause of each in-flight powerplant event.

Nomenclature.

Some ARAC ETOPS Working Group participants, representing the Part 135 community, would have preferred a nomenclature for long range operations that would be unique to 14 CFR Part 135 (such as Commercial On-Demand Extended Operations, or CODEOPS). While acknowledging that airplane and engine certification standards would be identical, the Part 135 community noted that on-demand operations are unique, differing significantly from operations conducted by 14 CFR Part 121 air carriers, and that these differences must be adequately reflected in the proposed rule. Part 135 operators are undertaken in small airplanes with a relatively small number of passenger seats by operators with a relatively small fleet offering infrequent on-demand service to a wide variety of possible destinations. They believed it was not entirely accurate, nor appropriate, to imply by using the same nomenclature, that the ETOPS operating requirements of 14 CFR Part 135 are identical to the ETOPS operational requirements in 14 CFR Part 121.

The Part 135 participants believed that naming long-range operations conducted in accordance with 14 CFR Part 135 the same as those operations conducted in accordance with 14 CFR Part 121 might cause confusion among pilots and airplane purchasers, as well as with FAA inspectors charged with oversight. This would be exacerbated by the fact that for nearly twenty years, FAA's "ETOPS" requirements only applied to 14 CFR Part 121 operations. A different nomenclature for 14 CFR Part 135 might make it clear that these were totally new requirements for 14 CFR Part 135 operators.

Other participants of the ETOPS ARAC Working Group indicated a preference for ETOPS. ETOPS ARAC Working Group had spent considerable time discussing nomenclatures for these extended diversion time operations. In the end, the working group concluded that the dual philosophy behind ETOPS (i.e., to preclude and protect airplane diversions) is applicable to all airplanes. Regardless of how many engines an airplane has, the rigorous design and disciplined maintenance processes of ETOPS will reduce the rate at which diversions occur, while ETOPS operational procedures will protect those few remaining diversions that do occur.

They also recognized that actual requirements may differ slightly among twins, tris, and quads, and that requirements may even differ among twin-engine operations depending on the maximum allowable diversion authority of the flight (i.e., under 120 minutes, 120 minutes, 180 minutes, 207 minutes, 240 minutes, or more than 240 minutes). Throughout all Part 121 operations, however, the underlying ETOPS concept of "preclude and prevent" remains applicable because it enhances all operations.

The group believes ETOPS should be applicable to Part 135 operations as well as Part 121 operations, because the preclude-and-protect ETOPS philosophy can enhance Part 135 "on-demand" operations just as it can those flown by all airplanes under Part 121. Only those requirements that make practical sense in Part 135 operations would be retained, so adopting the same ETOPS nomenclature as Part 121 will not necessarily mean that Part 135 operators would have to meet identical regulatory requirement. Further, Part 135 operators desiring to fly routes more than 180 minutes from the nearest adequate airport would comply with a new Appendix G of Part 135 detailing new procedures to increase the safety of those operations.

In the case of Part 135 operations, an FAA policy currently exists that limits these operations to 180 minutes from an adequate alternate airport. By way of comparison, three- and four engine airplanes currently operate under Part 121 without any limits of this nature. No regulations, policy letters, or advisory circulars of any kind restrict three- and four-engine Part 121 operations to 180 minutes. For Part 121 operations, the ARAC ETOPS group has recommended that even these three- and four-engine airplanes comply with ETOPS for operations beyond 180 minutes from an adequate airport. The group has already agreed that all airplanes operated under Parts 121 and 135 on ETOPS shall comply with the proposed Part 25 and Part 33 regulations. They believe that adopting the same ETOPS nomenclature will not alter any of the regulatory requirements that would be placed on Part 135 operations if such operations were permitted on routes more than 180 minutes from an adequate airport. The group further observes that it will serve to reassure the industry and traveling public at large if the FAA applies this same "preclude and protect" diversion concept to Part 135 operations on routes with a limited number of available en route alternate airports.

The Part 135 participants agreed that for harmonization among the operating rules that ETOPS be used to identify these long range operations. However, some members of the ARAC working group request the FAA to solicit comments on the 14 CFR 135 nomenclature issue in the proposed rule.

Type-Design. No specific type design approval has ever been required by 14 CFR Part 25 or 33 before an airplane can be flown over long-ranges in accordance with 14 CFR Part 135.

The proposed ETOPS rule was drafted to allow currently-certified airplanes to operate in accordance with ETOPS procedures without requiring a new type design approval. However, when an operator first applies to the FAA for approval to use a certain airplane in ETOPS (beyond 180 minutes from an airport), the operator must demonstrate that the airplane meets certain equipment requirements specified in the ETOPS Advisory Circular, or will achieve an equivalent level of safety through an alternate means.

The proposed changes to airplane and engine certification rules in this NPRM will apply to any airplane certified under 14 CFR Part 25, regardless of whether the airplane is to be operated in accordance with 14 CFR Part 135 or Part 121.

As newly designed airplanes are granted type-design approvals incorporating the requirements for ETOPS contained in 14 CFR Part 25 or 33, the flight manual will specify each time-limited system, and the maximum time that system can safely operate.

Transition. As no unique requirements for airplane type certification have ever been applied to long range flights conducted in accordance with 14 CFR Part 135, the proposed rule allows a transition period of eight years from the date the revised 14 CFR Parts 25/33 are published during which certificate holders may continue to add airplanes of current designs to their 14 CFR Part 135 fleets. After that date, the proposed rule requires that airplanes added to a certificate holder's fleet be type-certificated in accordance with the new ETOPS design requirements. This method of transition recognizes the excellent safety record of current airplane designs, and avoids penalizing certificate holders who may have made significant capital investments in airplanes. The length of this transition period was set at eight years because it is typical of the time required for a new, long-range turbine-powered airplane to go from initial design to the time it is commonly available to the majority of certificate holders. However, this transition period applies only to type design. The transition period will allow manufacturers to produce newly compliant aircraft and for those aircraft to become readily available in the aircraft marketplace. The operational practices required in 14 CFR 135 Subpart G would become effective immediately. These standards for operation, maintenance and dispatching of ETOPS would contribute to the continued safe operation of 135 long range aircraft operations.

Approved One Engine Inoperative Speed. When scheduled air carriers apply for route authority over a route requiring ETOPS, FAA approves a single one-engine inoperative speed for a specific route flown by that operator in a specific airplane model. This speed is then used to determine fuel reserves and maximum diversion distances for all subsequent flights. Unlike scheduled air carriers, an on-demand operator may only operate once over any given route-of-flight, and they must be able to do so with relatively short notice. Flexibility is required for ETOPS conducted in accordance with 14 CFR Part 135.

It is therefore not feasible to require pre-approval of a single one-engine inoperative speed for certificate holders operating ETOPS on each route in accordance with 14 CFR Part 135. Instead, when a certificate holder applies for ETOPS approval, the operator will suggest a range of speeds within the certified limits for a specific model of airplane. The FAA will approve this range of speeds for that operator. When planning for a specific flight, the certificate holder will select a single speed within this range and ensure that this selected speed is used to determine both fuel reserves and maximum diversion distances.

(Ed Note: Prior to the list of subjects, the FAA will include their analyses on a number of required subjects to include: paperwork reduction, international compatibility, economic impact, regulatory flexibility, trade impact, unfunded mandates, federalism, plain language, environmental impact and energy impact.)

List of Subjects

14 CFR Part [XXX] *[A list of the index terms for each part of 14 CFR cited in the heading of the NPRM. The terms are common words used to index the regulations of all agencies. The "List of Subjects," which provides the terms for each part contained in the Federal Register Thesaurus of Indexing Terms, is available from the Office of the Federal Register (OFR) or at http://www.nara.gov/fedreg/. Always use all the index terms found in the Federal Register Thesaurus for each part involved. The index terms must appear in alphabetical order separated by commas, with the first letter of each term capitalized. If two or more parts are affected by the proposal the following format must be used:]*

List of Subjects *List the parts in numerical order.*

14 CFR Part [XXX]

Insert appropriate index terms.

14 CFR Part [XXX]

Insert appropriate index terms.

The Proposed Amendment

In consideration of the foregoing, the Federal Aviation Administration proposes to amend part 1 of Title 14, Code of Federal Regulations, as follows:

PART 1 – DEFINITIONS

Section 1.1 General Definitions

Extended Operations (ETOPS): An approved operation for turbine engine powered airplanes, a portion of which is more than 60 minutes from an adequate airport for airplanes with two engines, or a portion of which is more than 180 minutes from an adequate airport for airplanes with more than two engines, or an area designated by the Administrator as an area of ETOPS applicability. ETOPS is calculated on an approved one engine inoperative cruise speed under standard conditions in still air.

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

Early ETOPS: Obtaining ETOPS type design certification without first gaining service experience on the airplane/engine combination to be certified.

ETOPS Configuration, Maintenance and Procedures Standard (CMP): Specific airframe / engine configuration minimum requirements including any special inspection, hardware life limits, Master Minimum Equipment List (MMEL) constraints and maintenance practices found necessary by the FAA to establish the suitability of that airframe / engine combination for ETOPS.

ETOPS Significant Systems:

Group 1 Systems:

Group 1 Systems are ETOPS significant systems that related to the number of engines on the airplane or the consequences of an engine failure make the system's capability important for an ETOPS flight. The following provides additional discriminating definitions of an ETOPS Group 1 Significant System:

(i) A system for which the fail-safe redundancy characteristics are directly linked to the number of engines (e.g., hydraulic system, pneumatic system, electrical system).

(ii) A system that may affect the proper functioning of the engines to the extent that it could result in an in-flight shutdown or uncommanded loss of thrust (e.g., fuel system, thrust reverser or engine control or indicating system, engine fire detection system).

(iii) A system which contributes significantly to the safety of an engine inoperative ETOPS diversion and is intended to provide additional redundancy to accommodate the system(s) lost by the inoperative engine. These include back-up systems such as an emergency generator, APU, etc.

(iv) A system essential for prolonged operation at engine inoperative altitudes such as anti-icing systems for a twin-engine airplane if single engine performance results in the airplane operating in the icing envelope.

Group 2 Systems:

Group 2 Systems are ETOPS significant systems that do not relate to the number of engines on the airplane, but are important to the safe operation of the airplane on an ETOPS flight. The following provides additional discriminating definitions of an ETOPS Group 2 Significant System:

(v) A system for which certain failure conditions "would reduce the capability of the airplane or the ability of the crew to cope with" an ETOPS diversion (e.g., long range navigation or communication, equipment cooling, or systems important to safe operation on a ETOPS diversion after a decompression such as anti-icing systems.

(vi) Time-limited systems including such things as cargo fire suppression and oxygen if the ETOPS diversion is oxygen system duration dependent.

(vii) Systems whose failure would result in excessive crew workload or have operational implications or significant detrimental impact on the flight crew's or passengers' physiological well being for an ETOPS diversion (e.g., flight control forces that would be exhausting for a maximum ETOPS diversion, or system failures that would require continuous fuel balancing to ensure proper CG, or a cabin environmental control failure that could cause extreme heat or cold to the extent it could incapacitate the crew or cause physical harm to the passengers).

(viii) A system specifically installed to enhance the safety of long-range operations and an ETOPS diversion regardless of the applicability of paragraphs (v), (vi) and (vii) above (e.g., SATCOM, GPS).

In consideration of the foregoing, the Federal Aviation Administration proposes to amend part 21 of Title 14, Code of Federal Regulations, as follows:

PART 21 --

Section 21.4 ETOPS Reporting Requirements

(a) Early ETOPS Problem Reporting & Tracking

(1) The holder of a type certificate of an airplane which has been approved for ETOPS without service experience in accordance with 14 CFR Part 25 Appendix L §L25.4(a) must establish a system to address problems encountered on engine and airplane systems that could affect the safety of ETOPS operations and timely resolution for these problems.

(2) The system must contain a means for: the prompt identification of ETOPS significant problems, the timely notification of the problem to the responsible FAA certification office, proposing to and obtaining FAA approval for the resolution of the problem. The implementation of the problem resolution can be accomplished by way of an FAA approved change(s) to the type design, the manufacturing process, or an operating or maintenance procedure.

(3) The reporting system must be in place for the first 250,000 fleet engine hours. For a twin-engine ETOPS airplane, the reporting requirement remains in place until the fleet has demonstrated a stable inflight shutdown rate in accordance with paragraph 2.b. below for the maximum diversion time for which the airplane has been certified.

(4) If the airplane or engine type certificated is a derivative of a previously certificated airplane or engine, the criteria of §21.4 may be amended by the Administrator to require reporting on only those significantly changed systems.

(5) For the early ETOPS service period, an applicant must define the sources and content of in-service data that will be made available to them in support their problem reporting and tracking system. The content of this data must be adequate to evaluate the specific cause of all service incidents reportable under § 21.3(c) of part 21, in addition to the occurrences that could affect the safety of ETOPS operations and must be reported, including:

(i) Inflight shutdown events, and for twin-engine ETOPS airplanes; inflight shutdown rates
(ii) Inability to control the engine or obtain desired power
(iii) Precautionary thrust reductions (except for normal troubleshooting as allowed in the aircraft manual)
(iv) Degraded propulsion inflight start capability

(v) Inadvertent fuel loss or availability, or uncorrectable fuel imbalance in flight
(vi) Technical air turn backs or diversions associated with an ETOPS Group 1 system
(vii) Inability of an ETOPS Group 1 system, designed to provide backup capability after failure of a primary system, to provide the required backup capability inflight.
(viii) A complete loss of any electrical power generating system or hydraulic power system during a given operation of the aircraft.
(ix) Any event that would jeopardize the safe flight and landing of the airplane on an ETOPS flight
(x) Unscheduled engine removals for conditions that could result in one of the reportable items listed above

(b) ETOPS Operational Service Reliability Reporting for Twin-Engine Airplanes

(1) Manufacturers of engines and airplanes used in ETOPS service must periodically report on the reliability of their twin-engine airplane fleets in service. Reporting must include:

(i) Propulsion system inflight shutdown events (excluding normal training events)
(ii) In-flight shutdown rates for all causes (excluding normal training events).
(iii) ETOPS fleet utilization, including operators, ETOPS approval authority, flight hours, cycles.

This reporting may be combined with the reporting requirements of § 21.3. The propulsion system inflight shutdown causes must be investigated by the manufacturer(s), and where appropriate for the safety and airworthiness of ETOPS operations, FAA approved corrective action must be implemented.

(2) ETOPS World Fleet In-flight Shutdown Rate Requirements. Manufacturers of engines and airplanes approved for ETOPS service must monitor and report the world-wide fleet in-flight shutdown rates by airplane-engine type combinations to ensure appropriate rates are maintained. ETOPS 12 month rolling average inflight shutdown rates must be maintained at the following levels:

(i) A threshold rate of 0.05 per 1000 fleet engine hours for twin-engine airplanes in ETOPS for initial approval up to 120 minutes, with continuing improvement toward a rate of 0.02 per 1000 fleet engine hours
(ii) A rate of 0.02 per 1000 fleet engine hours for twin-engine airplanes in ETOPS up to 180 minutes, and as provided for flight by flight exception based operations up to 207 minutes maximum diversion time in the North Pacific area of operation as defined in 14 CFR Part 121.
(iii) A rate of 0.01 per 1000 fleet engine hours for twin-engine airplanes in ETOPS beyond 180 minutes, except as provided for flight by flight exception

based operations up to 207 minutes maximum diversion time in the North Pacific area of operation as defined in 14 CFR Part 121.

(3)Exceedance of the above rates will require review by the certificating office of the FAA to determine if an unsafe condition that requires mandatory corrective action as specified by 14 CFR Part 39 exists. The rates contained in paragraph (b) are world-wide fleet rates applicable to ETOPS type design holders for a given airplane-engine type combination, and are not air carrier or operator specific.

In consideration of the foregoing, the Federal Aviation Administration proposes to amend part 25 of Title 14, Code of Federal Regulations, as follows:

PART 25 -- AIRPLANE TYPE DESIGN

Section 25.857(c)(2) There is an approved built-in fire extinguishing or suppression system controllable from the cockpit. The certified time capability of the system must be provided as required by §25.1581(a)(2) for ETOPS approval.

Section 25.1535 ETOPS Approval

Each applicant seeking type design certification for ETOPS must:

(a) Comply with the requirements of this Part considering the maximum mission time and the longest diversion time for which approval is being sought.

(b) Consider crew workload and operational implications and the flight crew's and passengers' physiological needs of continued operation with failure effects for the longest diversion time for which approval is being sought,

(c) Comply with the requirements of Appendix L of this Part.

14 CFR 25 Appendix L Extended Operations (ETOPS)

L25.1 Applicability This Appendix defines additional airworthiness requirements for the approval of an airplane-engine combination for Extended Operations (ETOPS) in accordance with §25.1535 of this Part.

L25.2 Design Requirements

a) Airplane Systems

i) Operation in icing conditions.

(1) The airplane must be certificated for operation in icing conditions in accordance with 14CFR §25.1419.

(2) The airplane must be capable of continued safe flight and landing at engine inoperative and decompression altitudes in icing conditions.

ii) The electrical power supply system must be designed so that -

(1) The occurrence of any failure condition which would prevent the continued safe flight and landing of the airplane on an ETOPS flight is extremely improbable, and

(2) The occurrence of any other failure conditions which would reduce the capability of the airplane or the ability of the crew to cope with adverse operating conditions on an ETOPS flight is improbable.

(3) For airplanes to be certificated for usage on routes further than 180 minutes from a suitable airport, the airplane must be equipped with at least three independent electrical generation sources.

iii) For each ETOPS significant system that is time limited, the system capability must be defined. The most limiting ETOPS significant system capability must be stated in the Airplane Flight Manual per the requirements of §L25.5.

b) Propulsion Systems

i) The airplane fuel system must maintain the engine inlet fuel pressure and flow required by section §25.955 to all operable engines throughout any ETOPS diversion, under any airplane configuration not shown to be extremely improbable.

(1) For twin engine airplanes to be certificated for usage on routes further than 180 minutes from a suitable airport, one fuel boost pump in each main tank and actuation capability of at least one crossfeed valve must be able to be powered by a back-up electrical generation source other than the primary engine driven or APU driven generators, unless the required fuel boost pressure or crossfeed valve actuation is not provided by electrical power.

ii) Fuel necessary to complete the ETOPS mission must be available to the operating engine(s) under any airplane failure condition not shown to be extremely improbable (e.g. crossfeed valve failures, automatic fuel management system failures).

iii) Alerts must be displayed to the flight crew when the quantity of fuel available to the engines falls below that level required to complete the mission. These alerts must include provisions for abnormal fuel management or transfer between tanks, and possible loss of fuel.

iv) If operation of the APU installation is required to comply with this Appendix, the applicant must substantiate that:

(1) The APU has adequate reliability for that operation, and

(2) If inflight start and run capability is necessary, the inflight envelope shall extend at least to the maximum operating altitude of the airplane, but need not exceed 45,000 feet.

L25.3 Additional Analysis Requirements for Early ETOPS

i) The following requirement is applicable to twin-engine airplanes only. An applicant seeking type design certification for Early ETOPS must identify specific corrective actions taken on the airplane design to be certified to address relevant design, manufacturing, operational and maintenance problems experienced on previously certified Part 25 airplanes manufactured by the applicant. Specific corrective actions are not required if the nature of the problem is such that it would not have a significant impact on the safety or reliability of the system. Relevant problems are those problems on ETOPS Group 1 significant systems that have or could have resulted in inflight shutdowns or diversions. To the extent possible, the relevant experience of supplier provided ETOPS Group 1 significant systems and similar or identical equipment utilized on aircraft built by other manufacturers must be included.

- **ii)** The following requirement is applicable to twin-engine airplanes only. Each applicant seeking type design certification for Early ETOPS on twin engine airplanes must substantiate by analysis, test, in service experience or other means that the propulsion system will minimize failures and malfunctions with the objective of achieving the following in-flight shutdown rates: 0.02 per 1000 engine fleet hours for ETOPS (180 minutes or less)
  0.01 per 1000 engine fleet hours for ETOPS (beyond 180 minutes).
- **iii) Engine Condition Monitoring.** The following requirement is applicable to all airplanes regardless of the number of engines. Procedures for an engine condition monitoring process must be defined and validated as required by Part 33 Appendix A,§33.3(c).

L25.4 Validation Methods. In order to establish if a particular airplane/engine combination has satisfied the requisite requirements for ETOPS, an assessment of the airplane/engine design combination must be conducted as part of the airplane design validation. One of the following methods must be used.

- a) **In-Service Experience.** Except as provided by paragraphs b) and c), an applicant may obtain ETOPS type design certification through demonstration of required reliability based upon fleet experience of the airplane/engine combination for which approval is sought.
  - i) After accumulating 250,000 world-wide fleet engine hours on the airplane/engine combination for which approval is sought, a reliability review must be performed.
  - ii) The number of hours may be reduced if adequate compensating factors are identified which give a reasonable equivalent database. Where experience on another airplane is applicable, a significant portion of the 250,000 hours should be obtained on the candidate airplane.
  - iii) The review required by this paragraph should be conducted utilizing reliability data for all airplane, propulsion and ETOPS significant systems. The applicant must establish that corrective actions for all causes or potential causes of engine in-flight shutdowns, loss of thrust control events, or failures of ETOPS significant systems occurring in service are effective in preventing future occurrences.
  - iv) **IFSD Targets Rates** For twin-engine airplanes, in order to be considered for ETOPS type design certification following the requisite service experience, the demonstrated world fleet propulsion system 12 month rolling average IFSD rates must be commensurate with the level of ETOPS approval being sought.
    - (a) For operations up to 120 minutes: A target threshold rate of 0.05 per 1000 fleet engine hours with a required list of corrective actions that would result in continuing improvement toward an IFSD rate of 0.02 per 1000 fleet engine hours.
    - (b) For operations up to 180 minutes: A target rate of 0.02 per 1000 fleet engine hours.
    - (c) For operations beyond 180 minutes: A target rate of 0.01 per 1000 fleet engine hours.

v) **Airplane System Assessment.** The requirements of §25.1535(a) shall be met using available in service reliability data for ETOPS significant systems.

vi) **Airplane Flight Test requirements.** A flight test must be conducted to validate the adequacy of the airplane's flying qualities, performance and the flight crew's ability to deal with engine inoperative and non-normal worst case probable system failure conditions.

vii) Configuration, Maintenance and Procedures. If the airplane, propulsion, and ETOPS significant system assessments identify configuration, maintenance or operational standards necessary to maintain appropriate reliability for ETOPS, the applicant must identify the appropriate standards in a Configuration, Maintenance and Procedures (CMP) document.

b) **Early ETOPS.** This paragraph provides the validation methodology for ETOPS type design suitability without first obtaining the fleet experience required by FAR 25 Appendix L §25.4(a) or (c) on the airplane/engine combination for which approval is sought.

i) **Testing.** For airplane, propulsion and ETOPS significant systems, the type and frequency of failures that occur during the airplane and engine validation programs must be consistent with the type and frequency of failures or malfunctions that would be expected to occur on presently certified ETOPS airplanes, or any non-ETOPS derivative models of those aircraft or engines.

(1) **Propulsion System Validation Test** The propulsion system for which approval is being sought on a twin engine airplane must be compliant with 14 CFR §33.90(b). The propulsion system for this test must be configured with the airplane installation nacelle and engine build-up hardware. At the conclusion of the test, the propulsion system must be:

(a) Visually inspected according to the applicant's on-wing inspection recommendations and limits.

(b) Completely disassembled and the propulsion system hardware must be inspected in accordance with the service limits submitted in compliance with § 25.1529. Any potential sources of inflight shutdown, loss of thrust control, or other power loss encountered during this inspection must be tracked and resolved in accordance with § L25.4 (b) ii)

(2) **APU Testing.** If utilizing an APU in order to meet the requirements of §L25.2(a)(ii) of this Appendix, one APU of the type to certificated with the airplane must complete a test consisting of 3000 equivalent airplane operational cycles. Following completion of the demonstration test, the APU must be disassembled and inspected. Any potential sources of inflight start and/or run problems must be identified, tracked and resolved in accordance with § L25.4(b)(ii).

(3) **Airplane Testing.** For each airplane/engine combination to be certificated, one or more airplanes must conduct flight testing which demonstrates that the aircraft, its components and equipment are capable of and function properly during ETOPS and ETOPS diversions. This flight testing may be coordinated with, but is not in place of flight testing required for compliance to 14 CFR 21.35(b)(2).

(a) The flight test program must include:
   (i) Flights simulating actual ETOPS operation including normal cruise altitude, step climbs, and APU operations if compliance to L25.2(b)(iv) is necessary to comply with this Appendix.
   (ii) Demonstration of maximum normal flight duration with maximum diversion time for which eligibility is sought.
   (iii) Engine inoperative maximum time diversions to demonstrate the airplane and propulsion system's capability to safely conduct an ETOPS diversion, including a repeat of a MCT diversion on the same engine.
   (iv) Non-normal conditions to demonstrate the airplane's capability to safely conduct an ETOPS diversion under worst case probable system failure conditions.
   (v) Diversions into representative operational diversionary airports.
   (vi) Repeated exposure to humid and inclement weather on the ground followed by long range operations at normal cruise altitude.

(b) The flight testing must validate the adequacy of the airplane's flying qualities, performance and flight crew's ability to deal with the conditions of paragraph (a)(iii), (a)(iv), and (a)(v) above.

(c) The engine-inoperative diversions must be evenly distributed among the number of engines in the applicant's flight test program except as required by paragraph (a)(iii).

(d) The test airplane(s) must be operated and maintained using the recommended operations and maintenance manual procedures during the airplane demonstration test.

(e) At the completion of the airplane(s) demonstration testing, the ETOPS significant systems must undergo an airplane visual inspection per the Instructions for Continued Airworthiness of §25.1529. The engines must also undergo a gas path inspection. These inspections are intended to identify any abnormal conditions that could result in an inflight shutdown or diversion. Any abnormal conditions must be identified, tracked and resolved in accordance with § L25.4 (b) ii)

ii) **Problem Tracking and Resolution System.** A problem tracking and resolution system must be established to address relevant problems encountered on the ETOPS significant systems during airplane and engine testing that could affect the safety of ETOPS operations.

(a) The system must contain a means for prompt identification of those problems that could impact the safety of ETOPS operations.

(b) The system must contain the process for the timely notification to the responsible FAA office of all relevant problems encountered, and corrective actions deemed necessary, in a manner that allows for appropriate FAA review of all planned corrective actions.

(c) The system must be in effect during the phases of airplane and engine development that will be used to assess early ETOPS eligibility.

(d) Upon Type Certification, the problem tracking and resolution system will revert to the requirements of 14 CFR Part 21 §21.4.

iii) **Maintenance and Operational Procedures.** The applicant must validate all ETOPS significant systems maintenance and operational procedures. Any problems found as a result of the validation must be tracked and resolved through the Problem Tracking and Resolution System required by §L25.4(b)(ii) of this Appendix.

c) **Combined Validation Methodology.**

i) The in-service experience requirements of paragraph a) may be reduced to 15,000 engine hours provided compliance to paragraph b)i)(1), b)i)(2), b)ii), b)iii) and L25.3 have been met.

ii) Additionally, as allowed by 14 CFR §21.21(b)(1), the in-service experience requirements of paragraph L25.4a) may be reduced provided compensating factors that provide an equivalent level of safety are provided.

L25.5 The maximum diversion time capability of the airplane for ETOPS must be defined in accordance with 14CFR §25.1581(a)(2), "Furnishing Information."

In consideration of the foregoing, the Federal Aviation Administration proposes to amend part 33 of Title 14, Code of Federal Regulations, as follows:

PART 33 -- ENGINE CERTIFICATION

Section 33.90 Initial maintenance inspection and early ETOPS tests

Each engine, except engines being certificated through amendment to an existing type certificate or through supplemental type certificate procedures, must complete one of the following tests on an engine that substantially conforms to the final type design:

(a) Initial maintenance inspection test: An approved test run that simulates the conditions in which the engine is expected to operate in service, including typical start-stop cycles, to establish when the initial maintenance inspection is required.

(b) Combined initial maintenance inspection and early ETOPS test. When required by section 33.100, approved tests of simulated ETOPS service operation and vibration endurance that consists of:

1. 3,000 representative service start-stop cycles (take-off, climb, cruise, descent, approach, landing and thrust reverse), plus three simulated diversions at maximum continuous thrust for the maximum diversion time for which ETOPS eligibility is sought. These diversions are to be approximately evenly distributed over the cyclic duration of the test, with the last diversion to be conducted within 100 cycles of the completion of the test.

This test must be run with the high speed and low speed main engine rotors unbalanced to generate at least 90 percent of the applicant's recommended maintenance vibration levels. For engines with three main engine rotors the intermediate speed rotor must be unbalanced to generate at least 90 percent of the applicant's recommended acceptance vibration level. The vibration level shall be defined as the peak level seen during a slow accel/decel of the engine across the operating speed range. Conduct the vibe survey at periodic intervals throughout the 3000 cycle test. The average value of the peak vibe level observed in the vibe surveys must meet the 90% minimum requirement. Minor adjustments in the rotor unbalance (up or down) may be necessary as the test progresses, in order to meet the required average vibration level requirement. Alternatively, to a method acceptable to the Administrator, an applicant may modify their test to accommodate a vibration level marginally less than 90% or greater than 100% of the vibration level required in lieu of adjusting rotor unbalance as the test progresses.

2. Each one hertz bandwidth of the high speed rotor service start-stop cycle speed range (take-off, climb, cruise, descent, approach, landing and thrust reverse) must be subjected to 3x106 vibration cycles. An applicant may conduct the test in any rotor speed step increment up to 200 rpm as long as the service start-stop cycle speed range is covered. For a 200 rpm step the corresponding vibration cycle count is to be 10 million cycles. In addition, each one hertz bandwidth of the high speed rotor transient operational speed range between flight idle and cruise must be subjected to 3x105 vibration cycles. An applicant may conduct the test in any rotor speed step increment up to 200 rpm as long as the transient service speed range is covered. For a 200 rpm step the corresponding vibration cycle count is to be 1 million cycles.

3. If the applicant chooses, it is permissible to conduct a complete visual inspection according to the applicant's on-wing inspection recommendations and limits, at an interval during the 3000 cycle test equivalent to an IMI test conducted in accordance with 33.90(a), in order to show compliance with the applicable requirements and obtain type approval, in advance of the completion of the full 3000 cycle test required by Section 33.90(b). Following an inspection acceptable to the Administrator, the 3000 cycle test will be resumed to fulfill the requirements of this section and 14 CFR 100(b).

Section 33.100 Early ETOPS Eligibility

Each applicant seeking engine type design eligibility for an engine to be installed in a twin-engine ETOPS airplane that does not have the service experience required by 14 CFR 25, Appendix L (para. L 25.4a):

(a) Must:

(1) have a design quality process to assure that features of the engine minimize the occurrence of failures, malfunctions, or maintenance errors that could result in loss of thrust control, inflight shutdown, or other power loss, and,

(2) show that the design features of the engine have addressed problems that have been shown to result in loss of thrust control, inflight shutdown, or other power loss, when compared to that applicant's other relevant type design approvals provided within the past ten years. Applicant's with less than ten years commercial engine service experience may show equivalent experience in a manner acceptable to the Administrator.

(b) subject the engine plus all associated components covered by the engine's Type Certificate to the testing required by Part 33.90(b).

(1)Prior to and following completion of the test, the engine must be subjected to a calibration test at sea level conditions. Any change in thrust characteristics at the conclusion of the test must be within certified limits.

(2)At the conclusion of the test the engine must be:

(i)Visually inspected according to the applicant's on-wing inspection recommendations and limits.

(ii)Completely disassembled. Engine hardware must be inspected taking into account the lessons learned from the applicant's design quality process from Section 33.100(a)1., and in accordance with the service limits submitted in compliance with section 33.4. Engine hardware shall not show distress to the extent that could result in loss of thrust control, inflight shutdown, or other power loss. Such hardware distress must have corrective action by way of design changes, maintenance instructions, or operational procedures. The type and frequency of hardware distress that occurs during the engine test must be consistent with the type and frequency of hardware distress that would be expected to occur on ETOPS eligible engines, or any non-ETOPS derivative engines of this type. Additional analysis and/or tests may be required to satisfy this requirement.

Appendix A, Instruction for Continued Airworthiness
A33.3(c)

(c) ETOPS unique requirements. For engines to be installed in twin-engine ETOPS airplanes, procedures for an engine condition monitoring process must be defined and validated for ETOPS type design eligibility. The engine condition monitoring process, for twin engine ETOPS airplanes only, must be able to determine, pre-flight, if an engine is no longer capable of providing, within certified engine operating limits, the maximum thrust required for a single engine diversion. The effects of additional engine loading demands (e.g., anti-ice, electrical), which may be required during an engine inoperative diversion, must be accounted for.

In consideration of the foregoing, the Federal Aviation Administration proposes to amend part 121 of Title 14, Code of Federal Regulations, as follows:

PART 121 -- AIR CARRIER OPERATIONS

Section 121.7 Definitions

Airports

Adequate Airport

1. For the purposes of those sections of 14 CFR 121 applicable to ETOPS, an adequate airport is an airport found by the Administrator to be equivalent to the provisions of 14 CFR 139, Subpart D safety requirements, excluding aircraft rescue and fire fighting service.
2. For the purposes of 14 CFR 121, an adequate airport is an airport that meets the landing performance requirements of 14 CFR 121.197

3. For the purposes of ETOPS, military airports that are active and operational, and meet the landing performance requirements of 14CFR 121.197, are considered to be adequate airports.

ETOPS Dual Maintenance Maintenance actions performed on the same element of identical, but separate ETOPS maintenance significant systems, during the same routine or non-routine visit. This is to recognize and preclude common cause human failure modes without proper verification process or operation test prior to ETOPS.

1) For turbine engine powered airplanes with two engines - A maintenance action performed on the same element of identical but separate ETOPS maintenance significant systems during the same routine or non-routine visit.

2) For turbine engine powered airplanes with more than two engines - A maintenance action performed on the same element of identical but separate ETOPS maintenance significant systems on 2 engines of a 3 engine aircraft, or more than 1 engine per side of a 4 engine aircraft during the same routine or non-routine visit.

ETOPS Alternate An airport listed in the certificate holder's operations specifications that meets the requirements of 14 CFR 121.624 and the Rescue and Fire Fighting (RFF) requirements of 14 CFR 121.106 designated in a dispatch / flight release that is planned for use while an airplane is en route to the destination during ETOPS if continued flight is inadvisable. (Note: This designation is a planning requirement. It does not in any way limit the decisions of the pilot in command during flight.) An ETOPS alternate must be an adequate airport with weather reports or forecasts or any combination thereof indicating that weather conditions are at or above operating minima specified in the certificate holder's operations specifications and with field condition reports indicating that a safe landing can be accomplished at the time of the intended operation. (from the earliest to the latest time of landing at that airport).

ETOPS Area of Operation

For turbine engine powered airplanes with two engines an area beyond 60 minutes from an adequate airport, or with more than two engines an area beyond 180 minutes from an adequate airport, and within the authorized ETOPS maximum diversion time approved for the operation being conducted, or an area designated by the Administrator as an area of ETOPS applicability. An ETOPS area of operation is calculated at an approved one engine inoperative cruise speed under standard conditions in still air.

ETOPS Maintenance Significant System

1) A system for which the redundancy characteristics are directly linked to the number of engines.
2) A system that may affect the proper functioning of the engines to the extent that it could result in an in-flight shutdown or uncommanded loss of thrust.
3) A system, which contributes significantly to the safety of a diversion.

ETOPS Entry Point
For turbine engine powered airplanes the ETOPS entry point is the first point on the route of an authorized flight which is more than 60 minutes from an adequate airport for airplanes with two engines, or 180 minutes from an adequate airport for airplanes with more than two engines, or a point designated as an entry point in an area designated by the Administrator as an area of ETOPS applicability. The ETOPS entry point is calculated at an approved one engine inoperative cruise speed under standard conditions in still air.

ETOPS Qualified Personnel Maintenance personnel that have completed the certificate holder's ETOPS training program.

Maximum Diversion Time For the purposes of ETOPS in 14 CFR 121.161 and related ETOPS regulations, maximum diversion time (e.g., 120, 180, 240, beyond 240 minutes) is the diversion time, under standard conditions in still air at one engine inoperative cruise speed (approved), as authorized by the Administrator.

One Engine Inoperative Cruise Speed (Approved) For the purposes of those sections of 14 CFR 121 applicable to ETOPS, one engine inoperative cruise speed is a speed within the certified operating limits of the airplane, selected by the certificate holder and approved by the FAA, that is used for calculating fuel reserve requirements and the still air distance associated with the maximum approved one engine inoperative diversion distance for the flight.

Following areas are defined for the purposes of those sections of 14 CFR 121 applicable to ETOPS

NOPAC The North Pacific ATS routes and adjacent airspace between Anchorage and Tokyo FIRs.
North Pacific Pacific Ocean areas north of 40oN latitudes including NOPAC ATS routes, and published PACOTS (Pacific organized track system) tracks between Japan & North America
Polar Areas - North Pole The entire area north of 78º N latitude
South Pole The entire area south of 60º S latitude

Section 121. 97(b)(1)(ii) Public protection including the availability of facilities at each airport or in the immediate area sufficient to protect the passengers and crew from the elements and to see to their welfare.

Section 121.99 Communications Facilities.
(a) Each certificate holder conducting domestic or flag operations must show that a two-way radio communication system or other means of communication approved by the Administrator is available at points that will assure reliable and rapid communications, under normal operating conditions over the entire route, including potential routes and altitudes to alternate airports, at normally planned

altitudes (either direct or via approved point-to-point circuits) between each airplane and the appropriate dispatch office, and between each airplane and the appropriate air traffic control unit, except as specified in 14 CFR 121.351(c).

(c) For ETOPS routes where voice communication facilities are available, voice communications shall be provided. As a minimum the requirements in (a) above apply if voice communications are not available. For all ETOPS operations beyond 180 minutes, the most reliable communication technology, either voice based or data link, must be installed. Where voice communication facilities are not available, and voice communication is not possible or is of poor quality, communications using alternative systems must be substituted.

Section 121.106 ETOPS Alternate: Rescue Fire Fighting Service

(a) Except as provided in (b) below, an airport rescue fire fighting service must be available at each airport designated as an ETOPS alternate in a dispatch or flight release.

(b) For dispatch, the minimum rescue fire fighting capability requirements are as follows: For ETOPS up to 180 minute diversion length, alternates must have rescue fire fighting capability equivalent to that specified by ICAO Category 4. For Two-Engine, 207 Minute operations, alternates must have rescue fire fighting capability equivalent to that specified by ICAO Category 4. In addition, at least one adequate airport within the 207 minute diversion time must have rescue fire fighting capability equivalent to that specified by ICAO Category 7. For all other ETOPS operations beyond 180 minutes, alternates must have rescue fire fighting capability equivalent to that specified by ICAO Category 7. If the necessary equipment and personnel are not immediately available at the airport, a 30 minute response time is deemed adequate if the initial notification to respond can be initiated while the diverting aircraft is enroute. Such equipment must be available on arrival of the diverting airplane and should remain as long as their services are needed.

Section 121.122 Communications Facilities.

(a) Each certificate holder conducting supplemental operations must show that a two-way radio communication system or other means of communication approved by the Administrator is available at points that will assure reliable and rapid communications, under normal operating conditions over the entire route, including potential routes and altitudes to alternate airports, at normally planned altitudes (either direct or via approved point-to-point circuits) between each airplane and the appropriate flight following center, and between each airplane and the appropriate air traffic control unit, except as specified in 14 CFR 121.351(c).

(b) For ETOPS routes where voice communication facilities are available, voice communications shall be provided. As a minimum the requirements in (a) above apply if voice communications are not available. For all ETOPS operations beyond 180 minutes, the most reliable communication technology, voice based or data link, must be installed. Where voice communication facilities are not available, and voice communication is not possible or is of poor quality, communications using alternative systems must be substituted.

Section 121.135(b)(10) For ETOPS, airplane performance data to support all phases of these operations.

Section 121.135(b)(23) (ed. assuming re-numbering in the item above is accomplished) For flag and supplemental operations, a passenger recovery plan applicable to each approved en route alternate airport listed in the air carrier's operations specifications. .

Section 121.161 Airplane limitations: Type of route.
(a) No certificate holder may operate a turbine engine powered airplane over a route that contains a point farther than 60 minutes flying time from an adequate airport for airplanes with two engines, or 180 minutes flying time from an adequate airport for airplanes with more than two engines (in still air at normal cruising speed with one engine inoperative) or within an area designated by the Administrator as an area of ETOPS applicability unless approved by the Administrator in accordance with Appendix N. The Polar areas are defined as an area of ETOPS applicability. ETOPS requirements are specified in the certificate holder's approved maintenance and operations programs. ETOPS must be authorized in the certificate holder's operations specifications and conducted in compliance with those sections of 14 CFR 121 applicable to ETOPS, including 14 CFR 121.633.
(b) Unchanged
(c) Unchanged
(d) Unless authorized by the Administrator, based on the character of the terrain, the kind of operation or the performance of the airplane to be used, no certificate holder may operate a piston engine powered airplane over a route that contains a point farther than 60 minutes flying time (in still air at normal cruising speed with one engine inoperative) from an adequate airport.

Section 121.368 ETOPS Maintenance Each certificate holder authorized to conduct ETOPS under 14 CFR 121. 161 shall comply with the following:
(a) Minimum requirements set forth in the Configuration, Maintenance and Procedures (CMP) for each airframe/engine combination, or the Type Design document for each airframe/engine combination. Any CMP changes necessary for continued safe ETOPS flights will be mandated through the normal Airworthiness Directive process. Revisions to the CMP may be issued to delete existing requirements, include alternate means of compliance or identify newly approved ETOPS configurations for a given airframe/engine combination.

(b) Develop and submit initial maintenance and training procedures established for ETOPS to the Administrator for approval.
(c) In addition to the basic minimum continuous airworthiness maintenance program requirements, the certificate holder shall develop and utilize a maintenance program including the following:

1. All CMP maintenance requirements, or Type Design Document maintenance requirements.

2. ETOPS Pre-departure service check, if required.
3. Verification procedures for corrective action to an ETOPS maintenance significant system
4. Maintenance procedures to preclude identical maintenance action performed on ETOPS maintenance significant items at the same visit, or compensating procedure to prevent identical human factor error.
5. Procedures to use if ETOPS dual maintenance cannot be avoided.
6. An APU in-flight start and run reliability program if an APU is required for ETOPS.

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(d) Establish procedures for centralized Maintenance Control related to ETOPS.

(e) Any changes to the maintenance and training procedures established to qualify for ETOPS shall be submitted to the FAA certificate-holding district office (CHDO) and approved before such changes may be adopted.

(f) Identify ETOPS specific procedures / tasks that must be accomplished or verified by ETOPS qualified personnel.

(g) Develop a document for use by personnel involved in ETOPS. All ETOPS requirements, including supportive programs, procedures, duties and responsibilities, shall be identified in this document and submitted for approval to the CHDO. This document needs not to be inclusive but should at least reference the maintenance programs and clearly define where they are located in the certificate holder's document system. Changes to the ETOPS document shall be submitted to the CHDO and approved before such changes may be adopted.

(h) Develop an ETOPS parts control program to ensure the configuration standard is maintained.

(i) Develop an ETOPS reliability program, or supplement their existing reliability program. The program should be event-oriented and incorporate reporting procedures for significant events detrimental to ETOPS flights.

(j) The certificate holder must conduct an investigation into the cause of each in-flight shut down in conjunction with manufacturers and submit findings to the CHDO. If the CHDO determines that corrective action is necessary, the certificate holder must implement the corrective action.

Should the certificate holder IFSD rate exceed the following values, an investigation into common cause effects or systemic errors must be conducted and findings must be submitted to the CHDO.

The following values are computed on a 12-month rolling average for two engine aircraft:

.05/1000 engine hours for ETOPS up to and including 120 minutes;

.03/1000 engine hours for ETOPS above 120 minutes up to and including 180 minutes, and 207 minutes in North Pacific; and

.02/1000 engine hours for ETOPS above 180 minutes, except for 207 minutes in North Pacific.

The following values are computed on a 12-month rolling average for aircraft with more than two engines:

.2/1000 engine hours for 3-engine ETOPS; and

.1/1000 engine hours for 4-engine ETOPS.

The report of investigation shall be submitted within 30 days through the CHDO to the Director of Flight Standard for approval of corrective action taken, if necessary.

(k) An Engine Condition Monitoring program to detect deterioration, at an early stage, and to allow for corrective action before safe operation is affected. For two engine airplanes the program shall ensure that engine limit margins are maintained so that a prolonged single-engine diversion may be conducted without exceeding approved engine limits (e.g. rotor speeds, exhaust gas temperatures) at all approved power levels and expected environmental conditions.

(l) An engine oil consumption program that considers manufacturer's recommendations, and is sensitive to oil consumption trends. It must consider the amount of oil added at the ETOPS departure station for the prevention of engine shutdown due to loss of oil. The APU should be included if an APU is required for ETOPS.

(m) If an APU is required for ETOPS, the certificate holder must have a cold soak in-flight APU start program to demonstrate acceptable start and run reliability.

Section 121.415(a)(4) Training for crewmembers and dispatchers in their roles and responsibilities in the certificate holder's passenger recovery plan.

Section 121.565 (a) Engine inoperative: Landing and Reporting.
(a) Except as provided in paragraph (b) of this section, whenever an engine of an airplane fails or whenever an engine is shutdown to prevent possible damage, the pilot in command shall land the airplane at the nearest suitable airport in point of time at which a safe landing can be made.

Section 121.624 ETOPS Alternates
(a) No person may dispatch an airplane for ETOPS unless the ETOPS alternates listed in the dispatch or flight release are located such that the airplane remains within the authorized ETOPS maximum diversion time under which the flight is to be dispatched. The operator must consider all airports within the diversion limits of the operation that

meet the standards of these regulations. Each required ETOPS alternate must be listed in the dispatch or flight release.
(b) No person may list an airport as an ETOPS alternate in the dispatch or flight release unless the appropriate weather reports or forecasts or any combination thereof indicating that weather conditions are at or above ETOPS alternate minima specified in the certificate holder's operations specifications and with field condition reports indicating that a safe landing can be accomplished at the time of the intended operation (from the earliest to the latest time of landing at that airport). Once a flight is enroute, the ETOPS alternates must meet the requirements of 121.631(c).
(c) No person may list an airport as an ETOPS alternate in the dispatch or flight release unless adequate airport services and facilities are available to support a safe approach and landing in the event of a diversion and to protect the passengers and crew following a diversion in accordance with criteria developed by the certificate holder and acceptable to the Administrator.

Section 121.625 Alternate Airport Weather Minimums

No person may list an airport as an alternate (except as required by 121.624) in the dispatch or flight release unless the appropriate weather reports or forecasts or any combination thereof indicate that the weather conditions will be at or above the alternate weather minimums specified in the certificate holder's operations specifications for that airport when the flight arrives.

Section 121.631 Original Dispatch Or Flight Release, Redispatch Or Amendment of Dispatch Or Flight Release.

Note: Re-sequence present item (c) to (e) and (d) to (f).
(b) Except as provided in 14 CFR 121.631(c) below, no person may allow a flight to continue to an airport to which it has been dispatched or released unless the weather conditions at an alternate airport that was specified in the dispatch or flight release are forecast to be at or above the alternate minimums specified in the operations specifications for that airport at the time the aircraft would arrive at the alternate airport. However, the dispatch or flight release may be amended en route to add any alternate airport that is within the fuel range of the aircraft as specified in 14 CFR 121.639 through 14 CFR 121.647.
(c) For ETOPS, in addition to 14 CFR 121.631(b) above, no person may allow a flight to continue beyond the ETOPS entry point unless the weather conditions at required ETOPS alternates specified in the dispatch or flight release are reviewed and forecast to be at or above the operating minimums specified in the operations specifications for that airport during the period in which that airport may be expected to be used (from the earliest to the latest time of landing at that airport). Such a review must include all ETOPS alternates within the dispatch diversion time of the planned routing and advice to the flight crew of any changes that have occurred since dispatch. However, the dispatch or flight release may be amended en route to add any ETOPS alternate with weather above operating minima and that is within the maximum ETOPS diversion time that could be authorized for that flight.

(d) Pilot in command for supplemental operators, or a dispatcher for flag operation, shall prior to the extended range entry point, use company communications to update any revised flight plan if required as a result of re-evaluation of aircraft system capabilities.

Section 121.633 ETOPS: Time Limited System Planning

(a) For ETOPS up to and including 180 minutes, the time required to fly the distance to the planned ETOPS alternate(s), at the approved one engine inoperative cruise speed, in still air and standard day temperature, may not exceed the time specified in the Airplane Flight Manual for the airplanes most time limited system time minus 15 minutes

(b) Except as provided in paragraphs (c) and (d), for ETOPS beyond 180 minutes, the time required to fly the distance to the planned ETOPS alternate(s), at the all engines operating cruise speed, correcting for wind and temperature, may not exceed the time specified in the Airplane Flight Manual for the airplanes cargo fire suppression system time minus 15 minutes

(c) Except as provided in paragraphs (b) and (d), for ETOPS beyond 180 minutes, the time required to fly the distance to the planned ETOPS alternate(s), at the approved one engine inoperative cruise speed, correcting for wind and temperature, may not exceed the time specified in the Airplane Flight Manual for the airplanes most time limited system time (except for cargo fire suppression) minus 15 minutes

(d) Three and four-engine turbine powered airplanes not meeting the requirements of 14 CFR 121.633(b) as of the effective date of this regulation may continue ETOPS operations for a period not to exceed 6 years from the effective date of this regulation.

Section 121.646 En Route Fuel Supply: Flag and Supplemental Operations

(a) No person may dispatch or release for flight or takeoff a turbine engine powered airplane with more than two engines more than 90 minutes (with all engines operating at cruising power) and less than 180 minutes (at the approved one engine inoperative cruise speed) from an adequate airport unless, considering wind and other weather conditions (including icing), it has enough fuel, assuming a rapid decompression at the most critical point followed by descent to a safe altitude in compliance with the oxygen supply requirements of 14 CFR 121.333, to fly to an adequate airport and conduct a normal approach and landing with enough fuel remaining to hold for 15 minutes at 1500 feet above field elevation.

(b) No person may dispatch or release for flight or takeoff a turbine powered airplane in ETOPS unless, considering wind and other weather conditions expected, it has enough fuel to satisfy (i) through (iv) below:

(i) Greater of :

> (A) fuel sufficient to fly to an ETOPS alternate assuming a rapid decompression at the most critical point followed by descent to a safe altitude in compliance with the oxygen supply requirements of 14 CFR 121.333, or

(B) fuel sufficient to fly to an ETOPS alternate at the approved one engine inoperative cruise speed assuming a rapid decompression and a simultaneous engine failure at the most critical point followed by descent to a safe altitude in compliance with the oxygen supply requirements of 14 CFR 121.333, or

(C) fuel sufficient to fly to an ETOPS alternate at the approved one engine inoperative cruise speed assuming an engine failure at the most critical point followed by descent to the one engine inoperative cruise altitude.

(ii) Upon reaching the alternate hold at 1500 ft above field elevation for 15 minutes and then conduct an instrument approach and land.

(iii) Add a 5% wind speed factor (i.e., an increment to headwind or a decrement to tailwind) on the actual forecast wind used to calculate fuel in (i) above to account for any potential errors in wind forecasting. If a certificate holder is not using the actual forecast wind based on wind model acceptable to the FAA, allow 5% of the fuel required for (i) above, as reserve fuel to allow for errors in wind data.

(iv) Compensate in (i) above for the greater of :

(A) the effect of airframe icing during 10 percent of the time during which icing is forecast (including the fuel used by engine and wing anti-ice during this period), or

(B) fuel for engine anti-ice, and if appropriate wing anti-ice for the entire time during which icing is forecast.

(c) Unless the certificate holder has a program established to monitor airplane in-service deterioration in cruise fuel burn performance and includes in fuel supply calculations fuel sufficient to compensate for any such deterioration, increase the fuel supply by 5% to account for deterioration in cruise fuel burn performance.

(d) If an APU is a required power source, then its fuel consumption must be accounted for during the appropriate phases of flight.

Section 121.687(a)(6) For each flight dispatched as an ETOPS flight, the ETOPS time basis (if any) under which the flight is dispatched.

Section 121.689(a)(8) For each flight released as an ETOPS flight, the ETOPS time basis (if any) under which the flight is dispatched.

<u>14 CFR 121 Appendix N Requirements for ETOPS Approvals</u>

The Administrator may approve ETOPS operations for various areas of operation in accordance with the requirements and limitations specified in this appendix.

A. ETOPS Authorizations: Airplanes with 2 engines

(a) 75 Minutes ETOPS

(1) Caribbean / Western Atlantic Area: Approvals may be granted to conduct ETOPS operations with maximum diversion times up to 75 minutes on Western Atlantic / Caribbean area routes without compliance with 14 CFR 121.161. The airframe/engine combination shall be reviewed by the Administrator to ensure the absence of factors that could prevent safe operations. The airframe/engine combination need not be approved for ETOPS; however, these operations must comply with the requirements of 14CFR 121.633. The certificate holder shall employ an FAA approved maintenance program that specifically addresses factors significant to 75 minute ETOPS operations.

(2) Other Areas Approvals may be granted to conduct ETOPS operations with maximum diversion times up to 75 minutes on other than Western Atlantic / Caribbean area routes without compliance with 14 CFR 121.161. The airframe/engine combination shall be reviewed by the Administrator to ensure the absence of factors that could prevent safe operations. The airframe/engine combination need not be approved for ETOPS; however, these operations must comply with the requirements of 14CFR 121.633. The certificate holder shall employ an FAA approved operations and maintenance program that specifically addresses factors significant to 120 minute ETOPS operations. Minimum equipment list requirements for 120 minute extended range ("ER") operations apply to such operations.

(b) 90 minutes ETOPS (Micronesia). Approvals may be granted to conduct ETOPS operations with maximum diversion times up to 90 minutes on Micronesian area routes without compliance with 14 CFR 121.161. For such operations the airframe/engine combination must be type design approved for 120 minute ETOPS. The certificate holder shall employ an FAA approved operations and maintenance program that specifically addresses factors significant to 120 minute ETOPS, except that a service check before departure of the return flight may not be required. Minimum equipment list requirements for 120 minute extended range ("ER") operations apply to such operations.

(c) 120 minutes. Approvals may be granted to conduct ETOPS operations with maximum diversion times up to 120 minutes. For such operations the airframe/engine combination must be type design approved for 120 minute ETOPS. The certificate holder shall employ an FAA approved operations and maintenance program that specifically addresses factors significant to 120 minute ETOPS. Minimum equipment list requirements for 120 minute extended range ("ER") operations apply to such operations.

(d) 138 Minutes.

(1) 120 Minute Exception. Approvals may be granted to conduct ETOPS operations with maximum diversion times up to 138 minutes. This authority is deemed to be an extension of already existing 120 minute ETOPS authority, and may only be exercised on a flight-by-flight exception basis. For such operations the airframe-engine combination must be type design approved for 120 minute ETOPS. In addition, airplane time-limited system capability may not be less than the authorized 138 minute diversion time in still air conditions at the approved one engine inoperative cruise speed plus a 15 minutes allowance for holding, approach and landing. The certificate holder shall employ an FAA approved operations and maintenance program that specifically addresses factors significant to 138 minute ETOPS. Operators with 120 minute ETOPS authority but no 180 minute authority may apply to AFS-200 through their certificate holding district office (CHDO) for a modified MEL which satisfies the MMEL policy for system / component relief in ETOPS beyond 120 minutes. The certificate holder shall submit for

FAA approval a summary of revisions to training curricula for maintenance, dispatch and flight crew personnel which identifies differences between 138 minute ETOPS diversion authority and its previously approved 120 minute ETOPS diversion authority

(2) Operators with existing 180 minute ETOPS approval. Approvals may be granted to conduct ETOPS with maximum diversion times up to 138 minutes to certificate holders with existing 180 minute ETOPS approval. This authority may be exercised on an unlimited basis. For such operations the airframe/engine combination must be type design approved for 180 minute ETOPS. The certificate holder shall employ an FAA approved operations and maintenance program that specifically addresses factors significant to 138 minute ETOPS. Approved minimum equipment list provisions for "beyond 120 minutes ETOPS" apply to these operations. The certificate holder shall submit for FAA approval a summary of revisions to training curricula for maintenance, dispatch and flight crew personnel which identifies differences between 138 minute ETOPS diversion authority and its previously approved 180 minute ETOPS diversion authority.

(e) 180 Minutes. Approvals may be granted to conduct ETOPS operations with maximum diversion times up to 180 minutes. For such operations the airframe/engine combination must be type design approved for 180 minute ETOPS. The certificate holder shall employ an FAA approved operations and maintenance program that specifically addresses factors significant to 180 minute ETOPS operations. Minimum equipment list provisions for "beyond 120 minutes ETOPS" apply to these operations.

(f) Greater than 180 minutes Approvals may be granted to certificate holders with previous ETOPS experience to conduct ETOPS with maximum diversion times exceeding 180 minutes as specified in subsections 1, 2, 3 and 4 of this section. Approvals may be granted only to certificate holders with existing 180 minutes ETOPS approval on the airframe/engine combination listed in their application. In conducting all such operations, operators shall make every attempt to minimize diversion time along the preferred track and plan ETOPS at maximum diversion distances of 180 minutes or less. If conditions prevent the use of adequate airports within 180 minutes as ETOPS alternates, the route may be flown beyond 180 minutes authority subject to the requirements provided for the specific area of operations. In addition to the maintenance and flight operations programs, MEL limitations for 180 minute ETOPS apply. In addition, the Fuel Quantity Indicating System (FQIS), APU (including electrical and pneumatic supply to its designed capability), Autothrottle system, most reliable voice-based communications technology or data link capability, and one engine inoperative autoland capability shall be operative for dispatch. For company communications, on such operations, operators shall use the most reliable communications technology available as per 14 CFR 121.99(c). Operators shall inform the flight crew any time an aircraft is proposed for dispatch under this authority and make available the dispatch considerations requiring such operations.

(1) North Pacific On flight by flight exception basis, tracked by the certificate holder, when an ETOPS alternate is not available within 180 minutes in the North Pacific area of operation, the nearest available ETOPS alternate must be specified within 207 minutes maximum diversion time. In conducting such operations the operator shall give ATS preferred track, if available, the first consideration. Application of this exception must be limited to circumstances such as political or military concern, volcanic activity, airport weather below dispatch requirements, temporary airport conditions and other weather related events. The airframe/engine combination shall be reviewed by the Administrator to ensure the absence of factors that could prevent safe operations. All requirements specified in the Configuration Maintenance and Procedures (CMP) Standard for 180 minute ETOPS are applicable.

(2) Polar Area (North Pole) and North of NOPAC On a flight by flight exception basis, tracked by the certificate holder, when an ETOPS alternate is not available within 180 minutes in the Polar Area (North Pole) or north of the North Pacific Area of Operations, the nearest available ETOPS alternate must be specified within 240 minutes maximum diversion time. Application of this exception shall be limited to circumstances related to the weather extremes particular to this area of the world such as volcanic activity, extreme cold weather at en route airports, airport weather below dispatch requirements, temporary airport conditions and other weather related events. The criteria used by the certificate holder to make determinations that extreme weather precludes the use of an airport must be established by the certificate holder and accepted by the FAA and published in the certificate holder's manual for the use of dispatchers and pilots. For such operations, the airframe/engine combination must be type design approved for 240 minute ETOPS. All requirements specified in the Configuration Maintenance and Procedures (CMP) Standard for 240 minute ETOPS are applicable to such operations.

(3) 240 minutes Area of Operations Approvals may be granted to certificate holders with previous ETOPS experience and existing 180 minute ETOPS approval on the airframe engine combination listed in their application to conduct ETOPS operations with maximum diversion times up to 240 minutes on routes in the Pacific oceanic areas between the US west coast and Australia, New Zealand and Polynesia; south Atlantic oceanic areas; Indian Oceanic areas; oceanic areas between Australia and South America. The operator must designate the nearest available ETOPS alternate(s) along the planned route of flight. For such operations, the airframe/engine combination must be type design approved for 240 minute ETOPS. All requirements specified in the Configuration Maintenance and Procedures (CMP) Standard for 240 minute ETOPS are applicable to such operations.

(4) Beyond 240 minutes Area of Operations- Approvals may be granted, to certificate holders who have been operating in accordance with 180 minute or greater ETOPS for 24 consecutive months, of which at least 12 consecutive months shall be at 240 minute ETOPS on the airframe/engine combination for which the authority is requested, to conduct ETOPS with maximum diversion times beyond 240 minutes between city pairs on routes in the Pacific oceanic areas between the US west coast and Australia, New Zealand and Polynesia; south Atlantic oceanic areas; Indian Oceanic areas; oceanic areas between Australia and South America. The operator must designate the nearest available ETOPS alternate(s) along the planned route of flight. For such operations, the airframe/engine combination must be type design approved for the maximum authorized ETOPS diversion time. All requirements specified in the Configuration Maintenance and Procedures (CMP) Standard for beyond 240 minute ETOPS are applicable to such operations.

B. ETOPS Authorizations: Airplanes with more than 2 engines

Approvals may be granted, for operations employing aircraft with more than 2 engines, to conduct ETOPS operations on a routine basis with maximum diversion times up to 240 minutes in any area of operations. For all such operations, the nearest available ETOPS alternate within 240 minutes diversion time (in still air at one engine inoperative speed) must be specified. If an ETOPS alternate is not available within 240 minutes, the nearest alternate ETOPS alternate must be specified. In either case the operator must designate the nearest available ETOPS alternate(s) along the planned route of flight. On all such operations, MEL limitations for ETOPS apply and in addition, the Fuel Quantity Indicating System (FQIS) and, if so equipped, SATCOM voice and SATCOM or HF Data Link must be operational. For company communications, on such operations, operators shall use the most reliable communications technology available per 14 CFR 121.99(c). For such operations, the airframe/engine combination must be type design approved for the maximum authorized ETOPS diversion time.

C. Polar Area (North & South Pole) and ETOPS beyond 180 minutes North of the NOPAC area

Approvals may be granted to conduct any operations within these areas. In granting such approvals, in addition to the requirements in subsections (A) and (B) above, the operator must consider airport requirements for enroute alternates, airline recovery plan for passengers at diversion alternates, fuel freeze strategy and monitoring, communication capability, Minimum Equipment List considerations, airline training issues specific to polar operations, long range crew requirements, dispatch and crew considerations during solar flare activity, special equipment requirements, and validation requirements for area approval in a manner acceptable to the Administrator.

Part 135

Section 135.98: Polar Operations

Except intrastate operations within the State of Alaska, no person may operate an aircraft in the region north of N 78^{o} 00’, designated as Polar, unless authorized by the

Administrator in the certificate holder's operation specifications, which must address the following items:

(1) Designation and requirements for airports that may be used for enroute diversions
(2) Recovery plan for passengers at diversion alternates
(3) Fuel freeze strategy and monitoring requirements for Polar operations
(4) Communication capability for Polar operations
(5) MEL considerations for Polar operations
(6) Training issues for Polar operations
(7) Crew considerations during solar flare activity
(8) Special equipment for Polar operations

Section 135.364 Multi-Engine Airplane Limitations: Maximum Distance From An Airport

Unless approved by the Administrator in accordance with Appendix G of this Subpart (Extended Operations (ETOPS)), no certificate holder may operate an airplane outside the Continental U.S. unless the planned route for that airplane remains within 180 minutes flying time (in still air at normal cruise speed with one engine inoperative) from an airport meeting the requirements of §135.385, §135.387, §135.393 or 135.395, as applicable, and §135.219 or 135.221 as applicable.

Section 135.345 Pilots: Initial, Transition, and Upgrade Ground Training:

(a)(9) ETOPS, if applicable
(a)(10) Passenger Recovery for ETOPS, if applicable

Part 135 Appendix G:
Extended Operations (ETOPS)

This appendix contains the requirements that a certificate holder must meet in order to conduct ETOPS. .

A. Definitions:

1. **ETOPS: Extended Operations**. ETOPS is an operation authorized under 14 CFR Part 135 pertinent to flights beyond 180 minutes flying time (in still air at normal cruise speed with one engine inoperative) from an airport meeting the requirements of §135.385, §135.387, §135.393 or 135.395, as applicable, and §135.219 or 135.221 as applicable. However, ETOPS flights must be planned so as to remain within 240 minutes flying time (in still air with one engine inoperative) from an airport meeting the requirements of §135.385, §135.387, §135.393 or 135.395, as applicable, and §135.219 or 135.221 as applicable.

2. **ETOPS Dual Maintenance**: Maintenance actions performed on the same element of identical, but separate ETOPS maintenance significant systems, during the same routine or non-routine visit. This is to recognize and preclude common cause human failure modes without proper verification process or operation test prior to ETOPS.

B. Certificate Holder Experience Prior to Conducting ETOPS

1. Prior to applying for authorization to conduct ETOPS, the certificate holder must have at least 12 months operating experience with a type of transport category turbine-engine powered airplane conducting international operations (excluding Canada and Mexico). For the purpose of this subparagraph, operations to or from the State of Hawaii may be considered as experience in international operations.
2. Certificate holders granted authority to operate under 14 CFR Part 135 or Part 121 before [*insert date rule is effective*] may credit up to 6 months of domestic operating experience (including Canada and Mexico) in a transport category turbojet airplane as part of the required 12 months of international experience.
3. A certificate holder's previous ETOPS experience with other aircraft types may be considered by the Administrator as meeting the requirements of paragraph (1) in whole or in part.

C. Airplane Requirements

1. No person may conduct ETOPS in a multi-engine airplane that was added to the certificate holder's U.S. operations specifications after [*insert date that is eight years after Part 25 Appendix L is adopted*] unless the airplane is certificated to §25, Appendix L.
2. No person may conduct ETOPS in a multi-engine airplane that was added to the certificate holder's U.S. operations specifications on or before [*insert date*

that is eight years after Part 25 Appendix L is adopted] unless the airplane is acceptable to the Administrator.

D. Certificate holder Requirements

1. No certificate holder may operate an airplane in accordance with ETOPS unless the planned route for that airplane remains within 240 minutes flying time (in still air and one engine inoperative) from an airport meeting the requirements of §135.385, §135.387, §135.393 or 135.395, as applicable, and §135.219 or 135.221 as applicable.
2. In addition to the requirements of §135.83, §135.225 and §135.229 the certificate holder will ensure flight crews have in-flight access to current weather and operational information on all enroute alternate, destination and destination alternate airports proposed for each ETOPS flight.

E. Operational Requirements

1. No pilot in command may allow a flight to continue beyond the ETOPS entry point unless the weather and operating conditions at the required enroute alternate airports are reviewed and expected to be at or above the operating minimums specified in the operations specifications during the period in which that airport may be expected to be used based on expected estimated times of arrival at that airport. The planned route of flight may be amended while en route to allow use of additional enroute alternate airports provided weather is forecast to be at or above operating minima and the airport is within the maximum ETOPS diversion time.
2. Pilots shall plan and conduct ETOPS under instrument flight rules.
3. Time Limited Systems:
   a. For ETOPS, the time required to fly the distance to the planned ETOPS alternate(s), at the all engines operating cruise speed, correcting for wind and temperature, may not exceed the time specified in the Airplane Flight Manual for the airplane's cargo fire suppression system time (if installed), minus 15 minutes.
   b. Except as provided in (a) above; for ETOPS, the time required to fly the distance to the planned ETOPS alternate(s), at the approved one engine inoperative cruise speed, correcting for wind and temperature, may not exceed the time specified in the Airplane Flight Manual for the airplanes most time limited system time (except for cargo fire suppression) minus 15 minutes.

Certificate holders operating turbine-engine powered airplanes not meeting the requirements of (a) and (b) above as of the effective date of this regulation may continue ETOPS operations for a period not to exceed [*insert date that is eight years after Part 25 Appendix L is adopted]*.

F. Communications Requirements

1. No person may conduct a ETOPS flight unless the following communications equipment, appropriate to the route to be flown, is installed and operational:

a. Two independent communication transmitters (at least one must allow voice communication).
b. Two independent communication receivers (at least one must allow voice communication).
c. Two headsets, or one headset and one speaker.

2. In areas where voice communication facilities are not available, or voice communication is not possible or is of poor quality, communications using alternative systems may be substituted.

G. Fuel Planning Requirements

1. No person may take off a flight for operations in ETOPS unless the fuel carried on board is the greater of :
   a. Fuel required under §135.223, or
   b. Considering forecast wind and other weather conditions, the airplane carries sufficient fuel to complete the flight under the conditions outlined in (i) through (iv) below (Critical Fuel Scenario):
      (i) Greater of :
         (a) Fuel sufficient to fly to a ETOPS enroute alternate airport assuming a rapid decompression at the most critical point followed by descent to a safe altitude in compliance with the oxygen supply requirements of §135.157.
         (b) Fuel sufficient to fly to a ETOPS enroute alternate airport at the approved one engine inoperative cruise speed assuming a rapid decompression and a simultaneous engine failure at the most critical point followed by descent to a safe altitude in compliance with the oxygen supply requirements of §135.157; or
         (c) Fuel sufficient to fly to a ETOPS enroute alternate airport at the approved one engine inoperative cruise speed assuming an engine failure at the most critical point followed by descent to the one engine inoperative cruise altitude.
      (ii) Upon reaching the enroute alternate airport, hold at 1500 ft above field elevation for 15 minutes and then conduct an instrument approach and land.
      (iii)Add a 5% wind speed factor (i.e., an increment to headwind or a decrement to tailwind) on the actual forecast wind used to calculate fuel in (i) above to account for any potential errors in wind forecasting. If a certificate holder is not using the actual forecast wind based on wind model acceptable to the FAA, allow 5% of the fuel required for a above, as reserve fuel to allow for errors in wind data.

(iv) Compensate for the greater of:

(a)The effect of airframe icing during 10 percent of the time during which icing is forecast.
(b)Fuel for engine anti-ice, and if appropriate wing anti-ice for the time during which icing is forecast,

2. Unless the certificate holder has a program established to monitor airplane in-service deterioration of cruise fuel burn performance and includes in fuel supply calculations fuel sufficient to compensate for any such deterioration, increase the fuel supply by 5 percent to account for deterioration in cruise fuel burn performance.
3. If the APU is a power source required by this appendix, then its fuel consumption must be accounted for.

H. Maintenance Program Requirements

1. Each certificate holder authorized to conduct ETOPS shall incorporate the following in its maintenance program:
    a. Aircraft must be maintained in accordance with a continuous airworthiness maintenance program in accordance with §135.411(a)(2) or a maintenance program under §135.411(a)(1) or an inspection program in accordance with §135.419.
2. In addition, the certificate holder's maintenance program will include:
    a. Maintenance procedures which address ETOPS dual maintenance that, when feasible, preclude common-cause human failure modes.
    b. Verification procedures following corrective action to a ETOPS maintenance significant system.
    c. An APU in-flight start and run reliability program if an APU is required for ETOPS.
3. In addition to the reporting requirements of §135.415, the certificate holder shall also report the following powerplant events to the Administrator as well as to the airframe and engine manufacturers.
    a. Engine shut downs, both on ground and in-flight, (excluding normal training events) including flameout,
    b. All occurrences where the intended thrust level was not achieved or where crew action was taken to reduce thrust below the normal level,
    c. Unscheduled engine removals for maintenance.
4. For each airplane authorized to conduct ETOPS, the certificate holder shall periodically report operating hours and cycles for each engine and airframe to the Administrator and to the airplane and engine manufacturer.
5. After consultation with the Administrator and the airplane and engine manufacturer, each certificate holder shall determine if corrective action for any reportable event required by §135.415 and paragraph (3) above is required. If the cause of an event is identified within a certificate holders area of responsibility, the certificate holder shall take immediate corrective action.

Issued in Washington, DC, on .

[The date of issuance is the signature date.]

[Name of Office Director]

[Title of Office Director]

Name and title of the individual signing the NPRM. Generally, the OPI director. If the individual signing the NPRM is "acting" for another individual, this must be noted in the signature block.

Appendixes to NPRM

ADVISORY CIRCULARS

AC 25-XX, "Type Design Approval for ETOPS"

Table of Contents

1 PURPOSE
This Advisory Circular (AC) states an acceptable means but not the only means of obtaining airplane Type Design Approval per the requirements of 14 CFR §25.1535 and 14 CFR §25 Appendix L for extended operations (ETOPS).

2 CANCELLATION
AC 120-42A, Extended Range Operation With Two-Engine Airplanes, dated December 30, 1988

3 RELATED 14 CFR SECTIONS
§21.3, §25 Sub-sections B, D, E, F, G, §33.90 and §33.100.

4 DEFINITIONS
The definitions in this section apply within the context of this AC with respect to ETOPS.

a) **Auxiliary Power Unit (APU).** A device (generally a gas turbine) intended for use as a power source for driving generators, hydraulic pumps, and other airplane accessories and equipment or to provide compressed air for airplane pneumatic systems, or both.

b) **Early ETOPS:** Obtaining ETOPS type design certification without first gaining service experience on the airplane/engine combination to be certified.

c) **Engine.** The basic engine assembly as supplied by the engine manufacturer.

d) **ETOPS Configuration, Maintenance and Procedures Standard (CMP):** Specific airframe / engine configuration minimum requirements including any special inspection, hardware life limits, Master Minimum Equipment List (MMEL) constraints and maintenance practices found necessary by the FAA to establish the suitability of that airframe / engine combination for ETOPS.

e) **ETOPS Significant Systems:**
<u>Group 1 Systems:</u>

Group 1 Systems are ETOPS significant systems that relate to the number of engines on the airplane or the consequences of an engine failure make the system's capability important for an ETOPS flight. The following provides additional discriminating definitions of an ETOPS Group 1 Significant System:

(i) A system for which the fail-safe redundancy characteristics are directly linked to the number of engines (e.g., hydraulic system, pneumatic system, electrical system).

(ii) A system that may affect the proper functioning of the engines to the extent that it could result in an in-flight shutdown or uncommanded loss of thrust (e.g., fuel system, thrust reverser or engine control or indicating system, engine fire detection system).

(iii) A system which contributes significantly to the safety of an engine inoperative ETOPS diversion and is intended to provide additional redundancy to accommodate the system(s) lost by the inoperative engine. These include back-up systems such as an emergency generator, APU, etc.

(iv) A system essential for prolonged operation at engine inoperative altitudes such as anti-icing systems for a twin-engine airplane if single engine performance results in the airplane operating in the icing envelope.

Group 2 Systems:

Group 2 Systems are ETOPS significant systems that do not relate to the number of engines on the airplane, but are important to the safe operation of the airplane on an ETOPS flight. The following provides additional discriminating definitions of an ETOPS Group 2 Significant System:

(v) A system for which certain failure conditions "would reduce the capability of the airplane or the ability of the crew to cope with" an ETOPS diversion (e.g., long range navigation or communication, equipment cooling, or systems important to safe operation on a ETOPS diversion after a decompression such as anti-icing systems.

(vi) Time-limited systems including such things as cargo fire suppression and oxygen if the ETOPS diversion is oxygen system duration dependent.

(vii) Systems whose failure would result in excessive crew workload or have operational implications or significant detrimental impact on the flight crew's or passengers' physiological well being for an ETOPS diversion (e.g., flight control forces that would be exhausting for a maximum ETOPS diversion, or system failures that would require continuous fuel balancing to ensure proper CG, or a cabin environmental control failure that could cause extreme heat or cold to the extent it could incapacitate the crew or cause physical harm to the passengers).

(viii) A system specifically installed to enhance the safety of long-range operations and an ETOPS diversion regardless of the applicability of paragraphs (v), (vi) and (vii) above (e.g., SATCOM, GPS).

Consideration for whether a system is ETOPS significant should include flight crew evaluation and FAA or JAA policy. For example, FAA MMEL policy letter PL-40 requires weather radar for ETOPS operations beyond 120 minutes, and FAA 207 ETOPS approval criteria (Federal Register Vol. 64, No. 80, Docket No. 29547, April 27, 1999) requires SATCOM for 207 minute ETOPS operation.

f) **Extended Operations (ETOPS):** An approved operation for turbine engine powered airplanes a portion of which is more than 60 minutes from an adequate airport for airplanes with two engines, or a portion of which is more than 180 minutes from an adequate airport for airplanes with more than two engines, or an area designated by the Administrator as an area of ETOPS applicability. ETOPS is calculated on an approved one engine inoperative cruise speed under standard conditions in still air.

g) **Extremely Improbable**. In context of this advisory circular, extremely improbable has a similar meaning to that used in 14 CFR §25.1309(b)(1) and as appropriate the guidance of AC 25.1309 should be used. However, at the time of issue of this AC no guidance is available for evaluating specific risk assessments such as an ETOPS flight. In the absence of any specific guidance a conservative approach should be used and the average flight risk assessments guidance provided by AC 25.1309 should be applied to the ETOPS specific risk mission. Guidelines for evaluating the specific risks described in this AC will be taken from revised AC 25.1309 as they become official.

h) **In-flight shutdown (IFSD):** When an engine ceases to function in flight and is shutdown, whether self-induced, crew initiated or caused by some other external influence (i.e., IFSD for all causes; for example: due to flameout, internal failure, crew-initiated shutoff, foreign object ingestion, icing, inability to obtain and/or control desired thrust, etc.)

i) **Powerplant Installation.** The powerplant installation includes each component that is necessary for propulsion, components that affect the control of the major propulsion units and components that affect the safe operation of the major propulsion units.

5 APPLICABILITY

This AC provides guidance to manufacturers seeking ETOPS type design certification for a particular airplane-engine combination.

Only those applicants that have experience in the manufacture of 14CFR Part 25 certified airplane-engine combinations will be considered eligible for Early ETOPS.

6 DISCUSSION

General All airplanes operated under 14CFR Part 121 are required to comply with §121.161. §121.161 imposes special requirements in order for a two-engine airplane to operate over a route that contains a point farther than 60 minutes flying time at an approved one-engine inoperative cruise speed in still air from an adequate airport and for an airplane with more than two engines to operate over a route that contains a point farther than 180 minutes flying time at an approved one-engine inoperative cruise speed in still air from an adequate airport. It is significant to note that this rule applies equally to airplanes operating over oceanic areas or routes entirely over land.

To conduct ETOPS, the specified airframe/engine combination must have been certificated to the airworthiness standards of transport category airplanes and must be approved for ETOPS per 14CFR Part 25.

Background Although originally evolving during the era of piston-engine airplanes, the requirements of §121.161 were effective and flexible enough initially to accommodate the increased reliability of turbine-powered airplanes. With the advent of a new generation of twin engine airplanes in the 1980s that had significant improvements in range, payload and reliability, a desire arose to take advantage of the capability of these airplanes and to establish conditions under which extended range operations could be conducted safely.
AC 120-42 in 1985 and AC120-42A in 1988 recognized the increasing reliability of turbojet engines and helped to establish type design and operational practices for safe and reliable long-range operations with two-engine airplanes. As the technology and reliability of twin engine airplanes continued to improve due, in a large measure, to the requirements of these documents, such operations became compatible with those long range operations typically associated with 3-4 engine airplanes. The data began to show that ETOPS requirements and processes are generally applicable to all long-range operations including those by three and four engine airplanes and would improve the safety and viability of all long range operations. Likewise, all airplanes could have time critical systems that are related to the maximum planned diversion and worst case scenarios. To address these issues, a reasonable approach was to incorporate many of the ETOPS requirements, based on sound safety principals and successfully proven over many years of operations, to all long-range operations.
14CFR Part 25 has now been changed to codify the beneficial design requirements from AC 120-42A, and where applicable, apply those practices to 3-4 engine airplanes desiring to fly ETOPS beyond 180 minutes. Additionally, methodology has been developed to allow twin engine airplanes to be designed for use beyond the current limitations imposed by AC120-42A.

7 CONCEPTS

Traditionally, existing ETOPS airplane/engine assessments conducted in accordance with AC 120-42A focus on two main objectives:

a) **Preclude any failure or malfunction that could result in an ETOPS diversion from intended flight; and**

b) **Protect the safety of the airplane and occupants during an ETOPS diversion**.

An ETOPS diversion is precluded by ensuring high reliability of the propulsion system and of all other systems important to ETOPS, and resolution of all problems that compromise the safety of ETOPS flight. Safety during the diversion is protected by build standards that ensure high reliability of the propulsion system and of those systems important to the diversion, ensuring adequate system capability and redundancy for the maximum diversion considered and resolution of all problems that compromise the safety of the diversion. While the in-service experience methodology of AC120-42A assured maturity prior to ETOPS approval, the early ETOPS criteria developed by the FAA in the early 1990's maintained this *Preclude and Protect* safety concept. The early ETOPS process relies on five main elements. A general description of the five elements follows:

Design for Reliability. The ETOPS requirements of Appendix L of CFR Part 25 require that the propulsion system be designed to preclude failures and malfunctions that could result in an engine inflight shutdown. Propulsion systems on previous airplanes were designed and certified to be "fail-safe", in compliance with §25.901 of Part 25; in other words, any single failure, or probable combination of failures, would not jeopardize continued safe flight and landing of the airplane. Because safe flight following an engine shutdown is required by Part 25, preventing inflight shutdowns had not been a major design objective on airplane designs prior to the introduction of early ETOPS. The additional design requirements of Appendix L to preclude failures and malfunctions that could result in an engine inflight shutdown has an enormous effect on propulsion system reliability in that normal design decisions must now consider whether a failure or malfunction might result in an engine inflight shutdown.

The ETOPS requirements of 14 CFR 25.1535 and Appendix L require that the airplane systems be designed to support the additional demands of an ETOPS flight and to ensure the airplane can safely conduct an ETOPS diversion in any probable failure condition. The intent is to preclude airplane system failure related diversions and if necessary to ensure the airplane has safe flight and land capability for an ETOPS diversion. The regulations provide additional focus on those airplane systems that have, historically, been important to ETOPS operations such as electrical power, APU and fuel systems. The emphasis on these specific airplane systems is not meant to be an indication that these are the only airplane systems that are important to ETOPS. The 14 CFR 25.1535 and Appendix L requirements along with the advisory circular guidance such as the ETOPS significant systems definitions, and the ETOPS scenario will ensure those other airplane systems can be adequately assessed for ETOPS.

Lessons Learned. An applicant seeking type design certification for Early ETOPS must identify specific corrective actions taken on the airplane design to be certified to address relevant design, manufacturing, operational and maintenance problems experienced on previously certified Part 25 airplanes manufactured by the applicant. Appendix L requires the airplane to be designed to prevent problems that have resulted in inflight shutdowns or diversion on previous airplanes (lessons learned). This process focuses on eliminating specific known failure causes from the new airplane design to allow some margin for unforeseen failure causes without having a detrimental effect on overall airplane and propulsion system reliability.

Test Requirements. Testing required by Appendix L and CFR §33.90(b) must prove the effectiveness of design features incorporated into the new airplane to prevent problems that have resulted in inflight shutdowns or diversions on previous airplanes. This validates that the specific lessons learned solutions work as intended, as well as assuring that the airplane, operating in a degraded condition, can perform an ETOPS diversion safely. The testing required is designed to discover basic design flaws to a greater extent than possible during basic Part 25 validation, including substantiating the suitability of any technology new to the applicant.

Demonstrated Reliability. Appendix L and CFR §33.100(b) requires that, for the airplane and engine systems, the number and types of failures during the airplane and engine testing must be consistent with the number and types of failures or malfunctions that would be expected to occur on presently certified long-range airplanes. This requirement gives the FAA assurance that the overall design maturity is at a level expected of current in-service ETOPS airplanes.

Problem Tracking System. Appendix L and CFR §33.100(b) require that problems that could impact the safety of ETOPS occurring during airplane development and certification testing must have proven fixes incorporated into the design before the airplane may be approved for ETOPS. All such problems occurring after the airplane begins ETOPS must be promptly reported in order that the FAA may require appropriate corrective actions. This requirement ensures that the risk of additional occurrences of any unforeseen failures that could affect the safety of ETOPS is low.

8 **ETOPS Scenario.** Each airplane/engine combination for which ETOPS type design certification is requested should be assessed to ensure it has adequate capability, capacity and system redundancy to safely conduct the operation. FAR Part 25, including Appendix L, with consideration for the ETOPS scenario defines the necessary requirements. The airplane and engine performance and failure analyses required for basic certification should be expanded to consider this scenario. Consideration should be taken for the potential increased crew workload effects associated with an extended diversion time under airplane system or engine failure conditions.

a) ETOPS Scenario Profile. The ETOPS scenario is summarized in Figure 1. This scenario is intended to make sure all possible long range flight conditions are considered in the evaluation of a particular airplane/engine combination. It is not necessary to consider all possible failure effects and environmental conditions in a single flight. Acceptable failure analyses such as described in AC 25.1309-1A, or later revision, should be used. The following provides examples of the possible situations that should be considered:

i) All engine climb through possible icing encounter to cruise altitude;

ii) For numerical probability analyses for Group 1 ETOPS significant systems the maximum normal ETOPS flight duration and maximum ETOPS diversion time. For numerical probability analyses for Group 2 ETOPS significant systems the average fleet mission, considering the ETOPS mission length should be considered. The applicant must consider how the particular airplane/engine combination is to be utilized, and analyze the potential route structure and city pairs available based upon the range of the airplane.

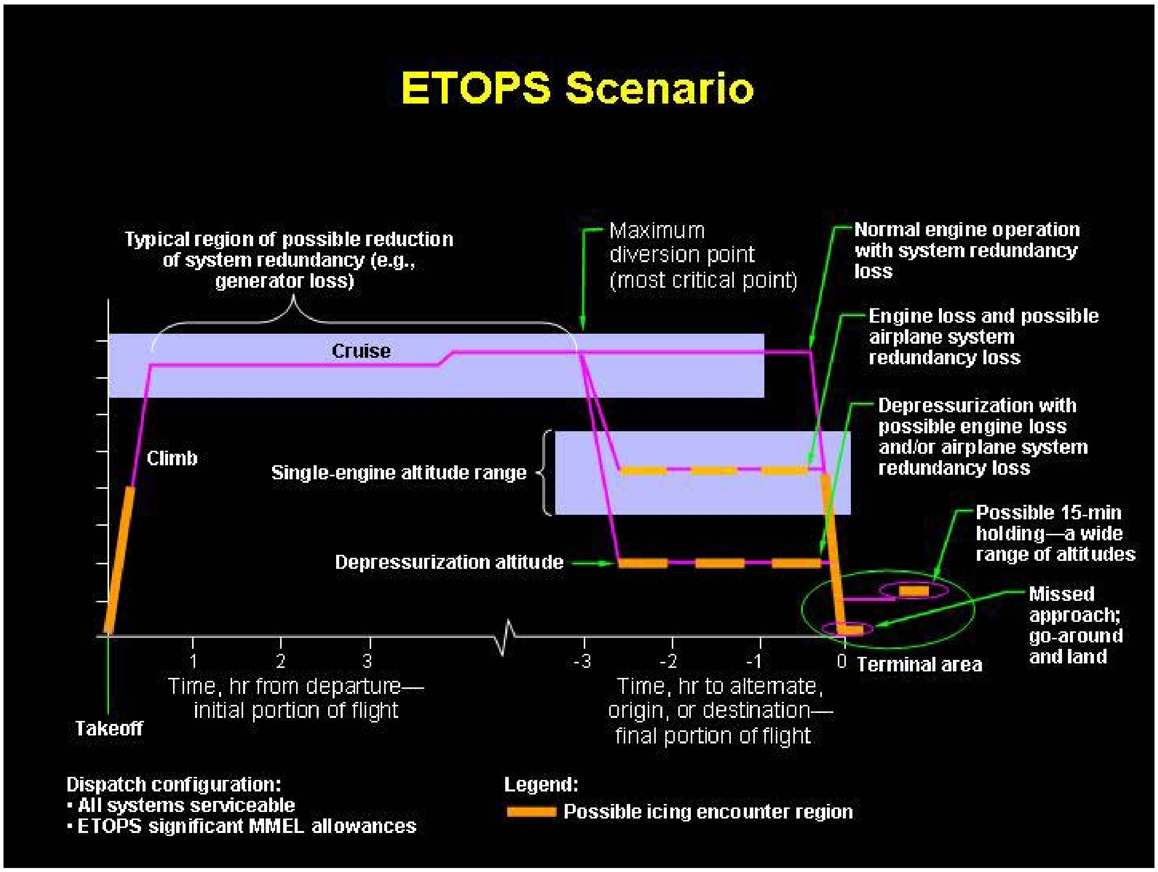
iii) During the cruise portion of the flight, it should be considered that the airplane will reach a point where it is the maximum certified distance from an airport. Leading up to this point, airplane system failures in flight which do not necessitate diverting the airplane should be considered. At the maximum diversion point, the most critical failure should be considered in combination with any other in flight failures which have been considered during the preceding cruise phase of flight.

(1) The most critical failures to be considered should include:
  (a) An engine(s) inflight shutdown;
  (b) Cabin decompression;
  (c) Combination of engine(s) inflight shutdown and cabin decompression;
  (d) Loss of system redundancy to the point where it is considered prudent to divert to the nearest suitable airport.
    (i) An example of this failure situation would be loss of electrical power generation redundancy down to a single main electrical source.

iv) The diversion should be considered to be conducted at both the engine(s) out cruise altitude (single engine inoperative for a twin, two engines inoperative for a tri or quad engine airplane), and the decompression scenario at 10,000 feet. During the diversion, possible icing encounters should be considered. The extent of the icing conditions should be substantiated by empirical data and analysis accepted by the FAA.

v) A fifteen minute hold, missed approach and go-around with possible icing conditions followed by landing should then be considered.

Figure 1. ETOPS Scenario



b) **Crew Workload Effects.** In assessing the fail-safe and redundancy features and effects of failure conditions, account should be taken of:

i) Variations in the performance of the system, the probability of the failure(s), the complexity of the crew action, and the type and frequency of the relevant crew training.

ii) Factors alleviating or aggravating the direct effects of the initial failure condition, including consequential or related conditions existing within the airplane which may affect the ability of the crew to deal with direct effects, such as the presence of smoke, airplane accelerations, interruption of air-to-ground communication, cabin pressurization problems, etc.

iii) Extended duration, engine(s) inoperative operations should not require exceptional piloting skills and/or crew coordination. Considering the degradation of the performance of the airplane type with engine(s) inoperative, the increased flight crew workload, and the malfunction of remaining systems and equipment, the impact on flight crew procedures should be minimized. Consideration should also be given to the effects of continued flight with an engine(s) and/or airframe system inoperative on the flight crew and passenger physiological needs (for example, temperature control).

iv) Adequate status monitoring information and procedures on all ETOPS significant systems are available for the flight crew to make pre-flight, in-flight go/no-go and diversion decisions.

9 Design Requirements

a) **Cargo Fire Suppression Systems**. The capability of the aircraft cargo fire suppression system required in 14CFR §25.857(c)(2) must be published in the FAA approved Airplane Flight Manual. The capability should be published in terms of suppression duration. The application of this duration will be managed by the requirements of the operating regulations, but should be applied considering an all-engine operative speed from an alternate airport when determining system capability and sizing. All-engine operation is considered because a cargo fire and an engine inflight shutdown are two independent events, the combination of which is less than extremely improbable and therefore need not be considered. An uncontained engine failure is a single event that could cause an inflight shutdown and a cargo fire, however for the uncontained event to cause a cargo compartment fire, the cargo compartment liner integrity would be compromised and therefore adequate Halon concentration can not be guaranteed regardless of the duration capability. In ETOPS, wind becomes an increasingly significant factor with increasing diversion times and should be considered in ETOPS beyond 180 minutes to assure that AFM system time limits are not exceeded.

b) **Operation in icing conditions**. Because ETOPS operations result in airplanes being relatively further away in time from alternate airports, and this additional time causes less certainty in weather predictions, it is appropriate that the airplane type design be shown to be able to operate safely in icing conditions. To ensure the airplane can operate safely in all potential icing conditions it might encounter on an ETOPS flight, the airplane must show compliance to CFR 25.1419 and show that it is capable of continued safe flight and landing at engine inoperative and decompression cruise altitudes for all icing conditions. For the purposes of type design compliance to 14 CFR 25 Appendix L §L25.2 (a) the probability of encountering icing should be assumed to be 1. Compliance to CFR 25.1419 is separate and distinct from the compliance to 14 CFR 25 Appendix L §L25.2 (a), however an airplane must comply with CFR 25.1419 to be eligible for ETOPS. It is not appropriate to combine the ice accumulation required for compliance to

CFR 25.1419 with the ice accumulation determined for compliance to 14 CFR 25 Appendix L §L25.2 (a).

The extent of ice accumulation on unheated surfaces for compliance to 14 CFR 25 Appendix L §L25.2 (a) should be based on empirical atmospheric data and should consider the maximum super cooled liquid water catch at engine inoperative and decompression cruise altitudes for the maximum approved diversion time. The probability of exceeding the super cooled liquid water catch in combination with the probability of associated airplane failures that would result in the airplane having to cruise in potential icing conditions, (i.e. engine inflight shutdown or decompression for this analysis) should be shown to be extremely improbable. If the airplane is equipped with sufficient supplemental oxygen to allow continued operation at altitudes above icing conditions for the maximum approved diversion time then the icing conditions during the decompression scenario do not need to be considered. If the engine inoperative cruise altitude is above icing conditions for all inflight airplane weight conditions then the icing conditions during the engine inflight shutdown scenario do not need to be considered.

The protected surfaces of the airplane, i.e. those surfaces that have deicing capability, must demonstrate that deicing is adequate for all icing conditions at engine inoperative and decompression cruise altitudes. The airplane must also meet the applicable airplane controllability and maneuverability regulations for all icing conditions. Any accumulation of ice must be accounted for in the compliance to 14 CFR 25 Appendix L §L25.2 (a).

c) **Electrical Power Availability/Reliability.**

In the L25.2(a)(ii) context, an electrical power supply system includes any non-time-limited electrical generator, whether driven by the aircraft engines, an auxiliary power unit, a hydraulic motor, or a ram air turbine, as long as the generator produces sufficient power for the equipment discussed below. It may also include time-limited sources (i.e. batteries), if the duration of the batteries is accounted for in the analysis.

Electrically powered functions required for continued safe flight and landing of an ETOPS flight normally include critical:

flight instrumentation,
warning systems,
engine controls,
fuel distribution necessary to complete the flight or a diversion
communications or critical navigation systems,
route or destination guidance equipment,
fire protection (cargo, APU and engine),
ice protection,

equipment cooling,
airplane environmental control and
any other critical equipment necessary for ETOPS.

Typically equipment providing critical functions is on the airplane's standby electrical bus. For fly-by-wire aircraft, this also includes the critical flight control system. In today's state-of-the art airplanes, a minimum of three electrical power supply sources are necessary to meet this requirement.

Electrically powered functions required to maintain the capability of the airplane or the ability of the crew to cope with adverse operating conditions for an ETOPS flight normally includes essential:
flightdeck and instrument lighting,
captain and first officer instruments,
engine inoperative auto-pilot,
any other essential equipment necessary for ETOPS.

d) **Fuel Quantity and Management Information.** As the primary consumable on the aircraft, the status of fuel quantity is critical for ETOPS. History of fuel loss events on transport category aircraft demonstrate that four equally important considerations must be included in the design of the aircraft to assure the safety of the flight in the event of a fuel leak:
i) Adequate fuel quantity indications and procedures to assure proper fuel loading prior to airplane departure.
ii) Prompt and proper identification of fuel anomalies to the flight crew,
iii) Adequate flight crew procedures to assure that the information provided is easily processed so that the leak can be isolated, and
iv) Proper isolation means and adequate feedback to the flight crew to assure awareness of the functioning of the fuel system, in particular any automatic features.

Three prominent events have occurred on transport category aircraft typifying the need for accurate indications and procedures:

- A twin engine airplane was loaded with an inadequate amount of fuel to complete the flight as a result of improper compliance with an MEL procedure. Both engines failed due to fuel exhaustion; the crew performed a successful "dead stick" landing at a non-operational airport along the flight path.
- A twin engine airplane on an ETOPS flight experienced a fuel leak in the engine. The fuel flow was enough for the engine to generate cruise thrust, but resulted in inadequate fuel to complete the mission. The crew did not detect the leak until another airplane informed the crew of leaking fluid. The crew performed a diversion with an uneventful landing.

- A twin engine airplane on an ETOPS flight experienced a fuel leak in the engine, but as in the previous instance, fuel flow was adequate to generate cruise thrust. Indications were provided to the flight crew, but the information was misinterpreted. Both engines failed due to fuel exhaustion; the flight crew performed a successful "dead stick" landing at a diversion airport.

Typical flight deck indications which can be utilized in determining the presence and location of fuel leaks include:

Fuel imbalance: This indication is present when the fuel quantity between main tanks differs by a pre-determined level. However, care must be given to potential masking of imbalance and leak problems by automatic transfer systems.

Fuel disagree: This indication is often present in automated flight management systems or flight management computers on current state-of-the art transport category airplanes. The presence of this message suggests that the flight management system has detected a difference between the amount of fuel measured by the automatic fuel quantity system and the measured fuel flow at the engine(s).

Insufficient fuel: This indication is also present in automated flight management systems when the predicted fuel, based upon fuel flow, is less than the pilot-entered or uplinked reserves.

The proper integration and reliability of these indications and others, coupled with the proper flight crew procedures and training, can assure suitable mitigation of the risk of fuel leaks or fuel migration.

e) **Airplane Fuel Feed System.** The fuel feed system needs to be able to supply fuel pressure within the operating specification of the engine, under all configurations not shown to be extremely improbable, i.e., must be able to show capability equivalent to those criteria required by AC 25.1309-1A. This includes the capability to cross feed fuel from one main tank to another for engine inoperative conditions. In most instances, this would require that those delivery fuel pumps and cross feed valves which are electrically operated to have a highly reliable electrical power supply. For twin engine airplanes to be certificated for usage on routes further than 180 minutes from a suitable airport, one fuel boost pump in each main tank and actuation capability of at least one crossfeed valve must be able to be powered by a back-up electrical generation source other than the primary engine driven or APU driven generators, unless the required fuel boost pressure or crossfeed actuation is not provided by electrical power.

f) **APU Installation.** In order to meet the reliability requirements for certain ETOPS significant systems, the APU may be required to be available during the flight. On some current ETOPS approved airplanes, the APU has been required for electrical redundancy on ETOPS flights; this has been accomplished both by demonstrating the in-flight start capability of the APU, and in some cases, by requiring continual operation of the APU throughout the flight. However, regardless of which ETOPS significant systems are utilizing the APU to meet reliability requirements, operation of the APU should have no negative impact on an ETOPS diversion.

(1) *Necessary Reliability.* Necessary reliability can be derived only by an understanding of the overall electrical system architecture on the airplane. For instance, if an applicant's electrical architecture relies heavily on the reliability of the APU generator then a more comprehensive demonstration program may be necessary. The reverse is also true - if the applicant's electrical architecture is such that there is very little dependence on the APU's availability then the APU generator is less critical, and the necessary reliability would be less. Nonetheless, with today's technology, it is not practical to assume that twin engine aircraft would be allowed to have a lower standard of APU/APU generator than is currently available.

If, during the accomplishment of the numerical probability analyses required by 14CFR §§25.1309 and 25.1535(a), it is shown that the APU must be available during flight, the analyses should define the necessary reliability of the APU. This definition may include the in-flight start reliability as well as the ability of the APU to perform its intended function during the flight. Following the development of this definition, the applicant must devise a test plan which will demonstrate the APU's capability to attain and maintain this objective.

(2) *Maximum in-flight start capability.* On current ETOPS approved airplanes, if APU in-flight start capability is necessary, the applicant has been required to demonstrate the capability of the APU to start throughout the operating envelope of the airplane. As service ceilings of modern transport category aircraft increase, it may be possible that state-of-the art technology will not assure starts at these higher altitudes. However, it is the intent of Appendix L §L25.2 (b)(iv)(2) that the APU should have inflight start capability throughout the operating envelope of the airplane. At the time of preparation of this Advisory Circular, capability for APU starts up to 45,000 feet have been demonstrated and therefore inflight start capability above that altitude are not required by the regulation. The major reason for wanting high altitude APU inflight start capability is to avoid having flight level changes that would cause the flight to have to cross through established flight track systems just to start the APU. Also, once the flight leaves the established track system it can be very difficult, or impossible to re-enter the track system, reducing the pilot's flexibility to fly the optimum flight plan. Having an inflight start capability up to 45,000 feet mitigates these concerns. If proper design considerations are applied early in the APU design and installation, including features such as reducing exhaust back pressure and boosting total inlet pressure recovery with a minimum loss inlet and higher inlet door position, the inflight start altitude can be significantly increased.

(3) *APU function throughout the flight envelope.* It should be a design target for the APU to provide those functions required by Appendix L throughout

the airplane operating envelope. Today's APU installations and their associated electrical generation systems are capable of providing full electrical power throughout the airplane operating envelope, and it is considered appropriate that future airplane designs produce similar results. Although current operations do not rely on APU pneumatic power, consideration should be given to the possible operational requirements for APU pneumatic capability on the ground in a divert scenario as outlined in the definition of Group 2 ETOPS significant system (vii). In all cases, APU operation, both electrical and pneumatic must permit continued safe flight and landing in all planned ETOPS scenarios. As discussed earlier having start capability up to 45,000 feet is generally considered adequate capability.

g) **Early ETOPS Propulsion System Design Requirements for Twin-Engine Airplanes.** A reliability assessment of the propulsion system must be made to predict the service entry IFSD rate. In determining the IFSD rate, all component or system failures previously encountered will be considered. If new failure modes or other problems are identified by analysis of the new design or during testing they must be incorporated into the predictions. The predicted IFSD rate must be assessed using established and accepted reliability analysis techniques.

1. The Engine manufacturer providing an engine expecting to gain ETOPS at Entry Into Service (EIS) must have a base of service experience upon which to derive reliability data for the engine sub-systems. Likewise, the airplane manufacturer must have a base of service experience upon which to derive the reliability data for the propulsion related aircraft sub-system(s). The most recent data and that from designs most similar to the model in application should be considered more prominently.
2. The engine manufacturer and airplane manufacturer must have, identify, and implement the techniques used to make IFSD predictions at the system, sub-system, and component level. Various methods or combinations of methods are suitable and appropriate depending on the detail level and the dominant failure mechanisms.
   (a) Widely used and accepted reliability analysis techniques include the FMEA/FTA approach. The FMEA and FTA are particularly suited for addressing previously unknown and random failures, or new design features.
   (b) Techniques that rely on examination and use of existing data can be particularly suitable for IFSD rate assessments. Examples include a Lessons Learned database, Historical Entry Rates, and Design Practices log. Historical Entry Rates, combined with Reliability Growth Analysis can provide a suitable prediction depending on the similarity of previous models and how well growth curves can be fit to existing data. These techniques may provide a more accurate assessment for operational or environmental effects on the propulsion system. In any event, all causes must be considered in analysis of the IFSD rate.

(3) Analysis ground rules and assumptions must be established and agreed to by the regulating authorities. The following summarizes important reliability

analysis ground rules and assumptions, but may not be comprehensive, and may be revised depending on agreement reached between the applicant and regulating authority.

(a) The new model anticipated average flight length should be used in analyses for IFSD rate assessment. This is appropriate because it corresponds to the previous substantiation of IFSD rates which was based on an entire fleet experience. Where longer flight length substantially affects (increases) the failure probability, the maximum flight length will be considered. The analysis must also then consider what effect the duty cycle will have on the failure rates. In general, IFSD's are driven by cyclic effects; therefore, increasing the flight length in the analysis process may have the unintended effect of reducing the conservatism in the analysis.

(b) Where latent failures may be present, the calculation of probability of occurrence will be based on the entire latency period.

h) **Relevant Experience Assessment.** Compliance to Appendix L §L25.3 should be shown by reviewing, for all Group 1 ETOPS significant systems, relevant experience on similar equipment and installations. While it is always good design practice to review past relevant experience when designing new equipment or new installations, because the Group 1 ETOPS significant system's reliability to provide its necessary function is limited by the number of engines special assessments must be made to ensure adequate reliability is achieved without the need for in service experience. The functions provided by Group 2 ETOPS significant systems do not rely on the number of engines and consequently their reliability can be adequately addressed by adding redundancy and therefore no additional assessment is necessary beyond that normally required to show compliance with 14 CFR §25. Relevant experience should include, but is not limited to:

i) Engine inflight shutdowns,

ii) Any failures or malfunctions which caused a diversion, or would have caused a diversion if it had occurred in a portion of the flight where a diversion would have been the most prudent action or would require a diversion by an inflight operational procedure,

iii) Any failure or malfunction that would significantly reduce the overall safety of a diversion.

iv) Manufacturing processes which resulted in a significant malfunction of a Group 1 ETOPS significant system. Variability in manufacturing processes, such as tolerance stack-up or batch-to-batch variations which have created significant malfunctions. For instance, a change in heat treat process embrittles an engine gearbox component which causes an inflight shutdown. This should be included as relevant experience of manufacturing variability.

v) Improper development or execution of maintenance manual instructions which result in a malfunction of a Group 1 ETOPS significant system, e.g., an incomplete test following a component removal/replacement.

vi) Operational problems resulting from any design deficiency, and either hardware or operational instructions.

The assessment should, following the generation of the above data, show how the design under consideration will address how similar problems are to be mitigated in the new application.

It is not considered practicable that an applicant, with no previous experience designing or manufacturing transport category airplanes, would be eligible to receive type design approval for early ETOPS on an aircraft. The benefits of the relevant design experience form the necessary basis which assures the reliability necessary for early ETOPS.

Engine Condition Monitoring.

The design and development of an Engine Condition Monitoring program is generally the responsibility of the engine manufacturer, but special consideration should be given to the integration of the program with the airframe. The engine condition monitoring process must be able to determine, pre-flight, if an engine is no longer capable of providing, within certified engine operating limits, the maximum thrust required for a engine inoperative diversion. The effects of additional engine loading demands (e.g., anti-ice, electrical), which may be required during an engine inoperative diversion must be accounted for. For twin-engine airplane the ECM program must be validated prior to ETOPS approval.

10 **Validation Methods**. Prior to the mid-1990's, the only method of obtaining ETOPS type design approval was by demonstrating the necessary reliability through in-service experience; today, this remains an acceptable means and is included in Appendix L, §L25.4(a). During the 1990's, several new and derivative twin-engine airplanes were developed and approved for initial ETOPS, which then subsequently entered service with adequate reliability. The early ETOPS validation means are also included in §L25.4(b).

Depending upon the production rate, daily utilization, and mission profile of the airplane type for which ETOPS approval is sought, a combination of early ETOPS and in-service experience validation methods may be desirable. This methodology is also now included in §L25.4(c).

a) **In-Service Experience.** In order to establish if a particular airframe/engine combination has satisfied the current propulsion system reliability requirements for ETOPS, a thorough assessment must be conducted by the applicant for submittal to the FAA utilizing all ETOPS significant system data and information available. Engineering and operational judgment supported by the relevant statistics will be used to determine current propulsion and airframe system reliability.

i) *Accumulation of world-fleet experience.* To provide a reasonable indication of airplane and propulsion system reliability trends and to reveal problem areas, a certain amount of service experience is required if early ETOPS design and analysis techniques are not implemented by the applicant. In general, extended range airframe/engine combination reliability assessments concern three major categories: those supporting up to 120 minutes maximum diversion time operations with twin-engine airplane/engine combinations; those supporting between 120 and 180 minutes maximum diversion time operations for two engine airplane/engine combinations; and those supporting beyond 180 minute maximum diversion times for all airplanes.

ii) *Reduction of in service experience.* Normally, accumulation of at least 250,000 engine hours in the world fleet is necessary before the assessment process can produce meaningful results. This number of hours may be reduced if adequate compensating factors are identified which give a reasonable equivalent data base. Where experience on another airplane is applicable to a candidate airplane, a significant portion of experience should be obtained on the candidate airplane. In the event that a particular engine is derived of an existing engine, the required in service experience is subject to establishing the degree of hardware commonality and operating similarities.

iii) *Propulsion system assessment*. In determining the suitability of a twin-engine airplane/engine combination for ETOPS, the accumulation of pertinent fleet data must be conducted. In the review of this data, engineering and operational judgment supported by the relevant statistics must be used to determine current propulsion system reliability. A propulsion system assessment must be based on the following data, collected from the entire fleet of the specific airplane/engine combination type for which approval is sought:

   (a) A list of all engine shutdown events both ground and in-flight for all causes (excluding normal training events) including flameouts. The list should provide identification (engine and airplane model and serial number), engine configuration and modification history, engine position, circumstances leading up to the event, phase of flight or ground operation, weather/environmental conditions, and reason for shutdown. In addition, similar information should be provided for all occurrences where control of desired thrust level was not attained.

   (b) Unscheduled engine removal rate (accumulated 6- and 12-month rolling averages), removal summary, time history of removal rate and primary causes for unscheduled removal.

   (c) Dispatch delays, cancellations, aborted takeoffs (includes those induced by maintenance or crew error) and en-route diversions chargeable to the propulsion system.

   (d) Total engine hours and cycles and engine hour population (age distribution).

   (e) Mean time between failure of propulsion system components that affect reliability

   (f) IFSD rate based upon a 6- and 12-month rolling average.

iv) In-flight shutdown rate targets. In order to maintain a level of safety consistent with the overall safety level achieved by modern airplanes, it is necessary for airplanes in ETOPS operations to have an acceptably low risk of significant loss of power or thrust for all design and operation related causes. To assure that the risks of increased diversion times are acceptable, several risk models have been developed by the industry. These models fall generally into two categories: "relative risk" models, and mathematical models based upon the Binomial Equation with reliability targets inserted. These models are discussed in detail in Appendix 1 of this AC, as well as the Preamble to CFR14 Part 25, Appendix L. In establishing the requirements for ETOPS beyond 180 minutes for twin-engine airplanes, the concept of the ETOPS Exposure Index, or EEI, was introduced. This concept is an extension of the "relative risk" model described in Advisory Circular 120-42A. The EEI provides an approach whereby several variables: mission length, average diversion distance, and inflight shutdown rate are considered in determining the risk on any given flight. The details of the EEI concept are also provided in Appendix 1. For the purposes of this section, it is important to note that EEI considers an important detail: the current maximum ETOPS diversion time doesn't represent "real world" risk, because in-flight shutdowns can and do occur anywhere along the flight track, not just at the maximum distance. Therefore, based upon the compilation of the "relative risk" model of AC120-42A and the EEI model (as well as other numerical derivations of Binomial Equation), the target inflight shutdown rates for ETOPS are as follows:

(a) *For twin-engine operation up to 120 minutes*: A threshold of 0.05 per 1000 fleet engine hours with a required list of corrective actions that would result in continuing improvement toward an IFSD rate of 0.02 per 1000 fleet.
(b) *For twin-engine operation up to 180 minutes:* 0.02 per 1000 fleet engine hours.
(c) *For twin engine operations beyond 180 minutes with no diversion time restrictions:* 0.01 per 1000 fleet engine hours.

These rates by definitions are **target** rates, and may not, in themselves, trigger action in the form of a change to the ETOPS design standard or reduction in the ETOPS approval status of the airplane/engine combination. The actual IFSD rate and its causes should be assessed with considerable engineering judgment. For example, a high IFSD rate early after the commencement of operation will undoubtedly be due to the limited number of hours contributing to the high rate. There may have been only one shutdown. The underlying causes must be considered carefully. A particular event may also warrant corrective action implementation even though the world fleet IFSD rate objective is being achieved.

v) *Airframe System Assessment.* Compliance to 14CFR §25.1309 is accomplished by the development of a comprehensive assessment which typically includes numerical analyses for systems whose function is required for continued safe flight and landing. In applying this same methodology to ETOPS significant systems on airplane/engine combinations desiring ETOPS approval, certain considerations must be taken, including the cascading risk associated with the increased stress on the remaining systems during a diversion.

In-service data on similar or same parts and components comprise the best source of data on which to base safety analyses that have as contributing events failure modes associated with these parts or components.

Two primary issues must be addressed for each analysis:

(1) **Failure Modes or Mechanisms.** The failure modes experienced in service must be shown to have been modeled correctly in the associated system analyses. This includes presence of the mode, and effect on the component, next higher assembly, and system and airplane level effects. As the airframe system assessments required by 14 CFR Part 25 Appendix §L25.4 (a)(v) are concerned with ETOPS significant systems, of particular importance are those failure mode and mechanisms which have or may have caused or contributed to a diversion or affected the safety of the diversion.

(2) **Failure Mode Rates.** Unlike failure modes or mechanisms for which a single occurrence constitutes a relevant data point, rates must be based on numerous occurrences (failures) to be statistically significant. Particularly, with failure modes with projected failure rates on the order of 1 X 10-5 or 10-6 or 10-7, years of experience at high utilization will be required to use directly calculated in service data. Inferences about modes with lower probability of occurrence can be drawn from the occurrence of dominant modes and the use of accepted failure mode distributions. However, the use of in service reliability data can be successful for those components and those component failure modes which fail more frequently, particularly those modes which have a rate of between 1 x 10-4 and 1 x 10-5, equivalent to an MTBF between 10,000 hours and 100,000 hours. The focus of application of in service data should be on components which fall into this range of failure rates and whose failure or malfunction may cause or contribute to the safety of a diversion. Examples include electrical generators, hydraulic pumps, fuel pumps, valves, control modules, and actuators. This also applies to certain event rates which may also be used in system assessments, for example, engine IFSD, APU IFSD and No-Start.

(3) When limited in service data is used, confidence bands and sensitivity analysis should be a part of the assessment process. This provides a quantitative measure of the uncertainty associated with the results of the safety analysis using in-service data.

vi) A flight test should be conducted by the manufacturer and witnessed by the FAA type certificate holding office to validate the expected airplane flying qualities and performance considering engine failure, electrical power losses, etc. during an ETOPS diversion. The adequacy of remaining airplane systems and performance and flight crew ability to deal with the ETOPS diversion considering remaining flight deck information should be assessed.

vii) Configuration, maintenance or operational standards required to resolve ETOPS significant in service events should be identified in a Configuration, Maintenance and Procedures (CMP) document.

b) **Early ETOPS Validation.** The testing required by this section is intended to demonstrate 1) the effectiveness of design features incorporated into the new airplane to prevent problems that have or could have resulted in IFSD's or diversions on previous airplanes, and 2) assurance that the airplane, operated in a degraded condition, can accomplish the maximum diversion safely. The validation plan must also include appropriate testing to substantiate the suitability of any technology that is new to the applicant.

i) *Type and Frequency.* Previous experience during validation programs has shown that a detailed review of the type and frequency of problems encountered is an important measure in attempting to determine the level of predicted reliability at entry into service. Engineering judgment must be applied in this review; the number of problems encountered in any type design certification program cannot be considered statistically significant, therefore, the applicant and the FAA will be required to perform a thorough root-cause investigation of each failure on an ETOPS significant system. In reviewing past airplane certification programs, evidence strongly suggests that those programs, which had few design problems during type certification, experience fewer in-service problems at entry into service. For this reason, a thorough review of the type and frequency of problems encountered during type design certification is necessary.

ii) **Engine Validation Test.** The requirements of 14CFR §33.90(b) must be met with a representative nacelle and engine build-up (EBU) installed. Typical EBU components include:

(1) Electrical generators
(2) Hydraulic pumps
(3) Customer (airplane) bleed air system
(4) Engine accessories not necessary for the generation of thrust, (i.e., fire detection systems, etc.).
(5) Thrust reversers, engine cowlings etc.

The intention of the nacelle/EBU installation is two-fold:

1. To assure the reliability of the installation items necessary for successful ETOPS missions, and
2. To create a proper vibration environment to properly "exercise" the ETOPS significant engine mounted components.

Where the vibration contribution of reverse thrust is unknown, the thrust reverser should be operational in order to transmit the proper vibration loads into the EBU and engine carcass (where appropriate). If the thrust reverser is powered by engine driven systems (hydraulic or pneumatic), the power should be extracted from the test engine. The engine driven electrical generator(s) should be connected to a load bank device which will allow the full electrical load to be produced, as well as adjustable to lower load offtakes. Production (or equivalent) electrical power generator controls and indicating systems should be used. The hydraulic system should be connected to a hydraulic load bank that is adjustable. Production (or equivalent) hydraulic system indications should also be installed and used. The aircraft bleed air supply system including cowl thermal anti-ice (where appropriate) should be installed on the engine. The bleed flows should be extracted from the engine through a pneumatic load bank capable of variable flow rates, up to the maximum flow requirements under worst-case airplane operation. The engine power settings should be adjusted according to engine ratings to compensate for the effect of bleed air extraction, where multiple ratings on an engine type are desired.

iii) **APU Testing.** The purpose of a test consisting of 3,000 equivalent operational cycles is to provide a test equivalence for the Auxiliary Power System (APS) which will approximate two years of typical revenue service. The APS is the defined as the APU itself, the APU fuel control and APU installation, for example electrical generator, starter, and plenum ducting, etc. Typical long-range airplanes will accumulate on the order of 2,000 hours and 1,500 cycles per year; variations on these utilization numbers should be considered when defining the exact number of cycles to be performed. To the greatest extent possible, the unit(s) and its installation to be tested should be a configuration that is equivalent to production.

(1) If in-flight start capability of the APU is required by §L25.2 (b)(iv), the cyclic endurance test should include a demonstration of the APU's ability to start at high altitudes and cold temperatures. In the event that the applicant does not have the facility to accomplish this test as part of the 3,000 cycle test, the applicant may perform these tests during the airplane flight testing.

(2) *Test Planning*. The major considerations of the APU cyclic endurance test, outside of those established above, include:

(a) **Cycle Mix.** An appropriate mix of cycle types which accumulate to 3,000 equivalent airplane operational cycles must be identified. The cycles should take into account proper installation loads (most typically pneumatic and electrical) to simulate in-service ETOPS flights and diversions. If the APU will be used to provide pneumatic power for main engine start, an adequate number of cycles with the equivalent level of pneumatic off-take must be performed.

(b) **Start mix.** If equipped with means to perform both electric and pneumatic starts, the applicant should assess the probable use of the APU and assure an appropriate mix of electrical/pneumatic starts is achieved.

(3) **Performance data.** Items such as oil consumption, performance deterioration, (gas path temperature, speeds, etc., for example), vibration and other critical parameters should be closely monitored and documented during the test. A post-test performance calibration should be performed to permit performance degradation evaluation. Shortfalls or excessive deterioration should be addressed prior to entry into service.

(4) **Maintenance demonstration.** The cyclic endurance test should also be performed using the maintenance publications that would be used by an operator. Inspections, LRU removal/replacements, oil uplifts and other maintenance tasks should be performed using the maintenance manual to assure proper tests and procedures have been developed.

(5) **Teardown Inspection.** Following completion of the test, the APU and its installation must be disassembled and inspected to identify all ETOPS

relevant failures or impending failures. Corrective action via design changes, maintenance instructions, or operational procedures identified by this inspection must be approved by the FAA and incorporated prior to ETOPS type design approval.

iv) **Airplane Testing.** In order to assure that the airplane/engine combination to be approved has successfully accomplished the intent of the early ETOPS design practices, flight testing must be performed to validate that the airplane successfully precludes diversions, and protects the airplane and its occupants during a diversion due to technical causes. The applicant must develop the flight test program based upon several criteria:

(1) **Flights simulating ETOPS operations.** The applicant should perform flights simulating representative ETOPS flights that the airplane fleet will likely experience in service. During these demonstration flights the airplane should be operated similar to normal in service operation, i.e. representative cruise altitudes, a typical number of cruise step climbs and throttle transients should be conducted. The duration of the flights should be sufficient to exercise all equipment that would normally be exercised on an ETOPS flight and to adequately cold soak equipment. If APU inflight start or operation is to be used to comply with the ETOPS requirements per L25.2 (b)(iv) then appropriate APU start and run operations should be included as part of the airplane demonstration tests, see AC paragraph (9)(f) for more details.

(2) **Demonstration of maximum normal flight duration.** At least one flight should be conducted for the maximum normal flight duration capability of the airplane. The maximum normal flight duration is based on the airplane's maximum takeoff gross weight capability and range capability with a passenger payload appropriate for the mission, e.g. multiple class seating if it is appropriate. The flight should be conducted using typical flight operations, e.g. cruise altitudes and number of cruise step climbs. This flight should demonstrate that there is no anomalous behavior when the airplane is flown for the maximum range expected in service. The last portion of the flight should simulate a maximum time diversion.

(3) **Engine inoperative maximum time diversions**. An adequate number of single engine diversions should be performed which demonstrate the airplane/engine capability to conduct maximum time diversions. Engine inoperative diversions should demonstrate, as a minimum, normal drift down procedures, decompression operation, representative throttle transients on the running engine and operation with the running engine at Maximum Continuous Thrust (MCT). A repeat of the MCT diversion should be conducted on the same engine unless there are engine operating limitations that restrict the operation. The diversions should be conducted for the maximum diversion time for which approval is sought. Normally a two engine database is adequate engine-to-engine variability. A two engine database is typically used for demonstrating inflight starting capability. If more than two engines are used in the flight test program the engine inoperative diversions should be distributed evenly amongst the flight test

engines. The recommendation above to repeat a MCT diversion on the same engine will necessarily limit the ability to evenly distribute the diversions among the flight test engines. It is considered more important to repeat the MCT diversion on a single engine then to obtain further distribution.

(4) Non-normal conditions. Non-normal, equipment inoperative conditions should be conducted to demonstrate the airplane's capability to safely divert under probable ETOPS significant system failure conditions. For those ETOPS relevant degraded airplane configurations for which non-normal procedures exist in the airplane operations manual, diversions should be demonstrated to assure the airplane and flight crew's capability to safely complete the diversion. The main purpose of these flights is to demonstrate the airplane's capability to safely divert with inoperative systems where reliance is on backup systems or system redundancy is reduced to a minimum. The number of flights to be conducted should be based on the variations of scenarios that need to be validated.

(5) Diversions into representative diversionary airports. The main intent of the ETOPS airplane flight demonstrations is to ensure the airplane is capable of operating safely in ETOPS and therefore diversions should be demonstrated into airports representative of those that might be used in ETOPS operations. If the airplane is expected to operate in several regions of the world then diversions should be conducted to each region where operation is expected. The diversions into ETOPS representative airport should be coupled with the non-normal system inoperative conditions required by L25.4(b)(i)(3)(a)(iv).

(6) Environmental variation. The design of the airplane/engine combination along with past service experience on similar products should be evaluated to determine what type of environmental condition have potential for causing problems at altitude that could potentially cause a diversion from cruise. Service experience has indicted that repeated operation into humid warm weather can cause problems with systems if the moisture is not properly drained. Moisture can become trapped in sense lines and other cavities and freeze at altitude causing erroneous indications. Repeated exposure to moist conditions is necessary to ensure condensation does not accumulate in unexpected areas and cause problems upon freezing. For designs that have sense lines that are open to the atmosphere the test plan should include repeated exposure to warm humid environments.

Other environmental conditions such as airport elevation and temperature should be evaluated to determine if there are any potential lingering affects at altitude that could cause a diversion. If so, appropriate conditions should be added to the flight test program to demonstrate the airplane/engine combination of interest is not susceptible.

v) A flight test should be conducted by the manufacturer and witnessed by the FAA type certificate holding office to validate the expected airplane flying qualities and performance considering engine failure, electrical power losses, etc. during an ETOPS diversion. The adequacy of remaining airplane systems and performance and the flight crew's ability to deal with the ETOPS diversion considering remaining flight deck information should be assessed.

vi) **Operation and maintenance of test airplane(s).** The test airplane(s) must be operated and maintained using the recommended operations and maintenance manual procedures during the airplane demonstration test.

vii) **Post test inspection.** At the completion of the airplane(s) demonstration test, a visual inspection of the airplane ETOPS significant systems should be conducted for any obvious damage or impending failures that could potentially cause a diversion or significantly reduce the safety of a diversion. This inspection should use the airplane Instructions for Continued Airworthiness of §25.1529. Corrective action, whether design changes, maintenance instructions or operational procedures must be identified, tracked and resolved in accordance with §L25.4(b)(ii).

c) **Problem Tracking and Resolution Plan.** A process must be established which contains a means for the prompt identification of relevant problems as well as a process for the timely notification to the FAA of those problems and planned resolution. In some cases, engineering or operational judgment may be required to determine the reportability of a problem or the appropriateness of the planned resolution. If the status of a problem or resolution changes due to consideration of further data or refinement of judgment, the applicant must promptly notify the FAA.

The time interval from the determination of reportability until the FAA is notified should be no longer than 24 hours. In the event a specific problem is not reported to the FAA within the time interval specified, the applicant will report the problem as soon as is reasonably possible.

The problem reporting and resolution plan will be characterized by a phased approach whereby reporting to the FAA, and FAA involvement in the process increases as an airplane type continues toward certification and entry into service. During development testing, reporting is limited to program and test status; significant problems are described and statused between the applicant and the FAA. As the development program proceeds into ETOPS testing and flight testing, reporting should be expanded to address ETOPS reportable events as defined below, and reporting frequency and FAA involvement increases.

(1) **ETOPS Problem Reporting Criteria**

The types of problems reported to the FAA vary with the phase of an airplane/engine development program. During development testing, including qualification testing, problems will generally be reported through applicant specialist interchange with the FAA. During ETOPS engine and APU ground testing and flight testing, reporting is formalized and minimum criteria for problems to be reported are identified.

The reporting requirements are considered guidelines and establish minimum criteria for event reporting. The following paragraphs contain the majority of events to be reported but cannot be totally inclusive. Other events as determined by applicant specialists or DER's should be reported.

For an event to be considered reportable, it must be encountered in an activity used to assess ETOPS suitability, such as the engine cyclic validation test, APU cyclic testing and flight testing (as necessary for both Part 25 and ETOPS validation). It must involve a part, system, engine, or APU that has no appreciable functional differences from the intended production configuration at the time of the event.

Events should be reviewed by the applicant specialists and DER's for their effect on ETOPS operations and reportability to the FAA. As part of this review, each event should be considered to determine if the same occurrence under different operational circumstances could meet the reportability criteria. In some cases, technical judgment will be required to understand the component functions, evaluate the airplane level effects, and determine reportability. Fault trees or functional hazard analyses may be used to assist in this evaluation. If, when analyzed, such an event did or could meet the criteria, then it will be considered to be reportable. Examples of reportable events include:

Non-discretionary inflight shutdowns

Inability to control the engine or obtain desired thrust

Precautionary thrust reductions (except for normal troubleshooting as allowed in the aircraft manual)

Degraded propulsion inflight start capability

Inadvertent fuel loss or availability, or uncorrectable fuel imbalance in flight

Inability of a Group 1 ETOPS significant system, designed to provide backup capability after failure of a primary system, to provide the required backup capability inflight

Any event that would jeopardize the safe flight and landing of the airplane on an ETOPS flight

Any event that would reduce the capability of the airplane or the ability of the crew to cope with adverse operating conditions on an ETOPS flight

ETOPS Event Resolution Process. The applicant must provide to the FAA, in addition to the reporting criteria above, a process by which the ETOPS significant events will be resolved. Typical process phases include problem identification, assignment to proper organization, problem determination and solution definition, implementation, and closure. The applicant must provide to the FAA means of identifying the status of the resolution at any point during the process.

Configuration, maintenance or operational standards required to resolve the ETOPS significant events must be identified in a Configuration, Maintenance and Procedures (CMP) document unless all applicable airplane-engines of a particular type are certified and delivered with that standard.

ii) **Maintenance and Operational Procedure Validation.** All maintenance and operational procedures associated with Group 1 and 2 ETOPS significant systems should be validated as part of the Early ETOPS program. The method of validation may be different for different procedures. The validation program for all procedures should be approved by the FAA. During all testing required for ETOPS validation, the airplane, engine, and component maintenance manuals should be utilized for all maintenance activities. Line-replaceable unit removal/replacement should be demonstrated, maintenance intervals defined in the maintenance manuals should be adhered to, and replacement testing should be performed per the published procedures. During ETOPS flight validation, the operating procedures intended for use by the airline operators should be utilized. Any maintenance or operational procedures which are incomplete or incorrect should also be reported to the FAA per the Problem Tracking and Resolution process denoted above.

d) **Combined Validation Methodology**

i) The rationale for this approach is the precedents established by the Airbus A330 and Boeing 737 "Next Generation" aircraft. In the case of the Boeing 737, the FAA concurred with the Boeing proposal, which stated that by following the early-ETOPS processes (short of performing a dedicated flight test), an accumulation of 15,000 fleet hours would be adequate to demonstrate suitability for 180 minute ETOPS. This was based upon:

- A validation program which included all aspects of the 777 early ETOPS special condition except for a dedicated airplane flight test, i.e.,
    - Relevant experience assessment
    - Propulsion system 3000 cycle ground test
    - Problem tracking and resolution
    - Maintenance and operations procedures validation
- The allowance granted by AC 120-42A to reduce the service experience requirement
- The excellent reliability during flight testing
- Diversion experience (3 separate 180 minute single engine diversions) during the Functional & Reliability (F&R) testing
- The proven ability of Boeing to satisfactorily manage ETOPS airworthiness (based upon B777 experience).

ii) Appendix L25.4(c)(ii) also allows the in-service experience requirements of paragraph L25.4(a) to be reduced provided compensating factors provide an equivalent level of safety. The intent is that the compensating factors are bounded by the in service requirements of paragraph L25.4(a) and the early ETOPS validation prescribed by paragraph L25.4(b) and L25.3.

Appendix 1

Risk Models

The need for redundancy in certain systems of commercial airplanes is obvious. The propulsion system is one such system which requires redundancy in order to make the airplane sufficiently safe for commercial use.

Early in the development of commercial aviation it became apparent that airplanes with only two engines could not safely fly long distances from a suitable landing site. The engines were simply not reliable enough to assure that the flight could arrive at its destination with a least one engine operating. In 1949 an FAA regulation was written for twin engine airplanes which required them to remain within 60 minutes of a suitable airport. This was an appropriate rule for that time.

Thirty years later the reliability of engines had increased by orders of magnitude, but the 1949 rule remained as written. There were some operators which were allowed to fly their twin engine airplanes further from suitable airports under specific dispensations, but the vast majority of commercial twins were still flying to the 1949 rule. Even now ETOPS is not allowed by rule.

A petition to allow longer times from suitable airports was made to the FAA during the early 1980's. After lengthy deliberations among regulatory agencies, airplane manufacturers, engine manufacturers, and operators, 120 minutes from a suitable airport was allowed in 1985.

A further extension to 180 minutes was made in 1988 under AC 120-42A which is still the guiding US ETOPS document.

In both the 120 and 180 minute rules the FAA made extensions in diversion time based on extrapolation of demonstrated engine reliability. The JAA, Transport Canada, and ICAO used an approximation of the probability of an engine failure in flight followed by failure of the second engine from independent causes during the time to return to base, fly on to the destination, or divert to a suitable airport.

All of the ETOPS "rules" have guidelines for engine reliability that are expected to be met in order to maintain ETOPS status. The current 180 minute guideline is 0.02 IFSD's per 1000 engine flight hours.

Discussion

During early deliberations on codifying the ETOPS rule under the current ARAC ETOPS charter, the FAA proposed a simple algorithm that maintained a consistent level of risk for two engine failures during the same flight resulting from independent causes. The algorithm called the ETOPS Exposure Index, EEI, was based on the underlying probability equation for two independent engine failures shown in equation (1), but was expressed in terms of flight distance, mean diversion distance, and engine failure rate as shown in equation (2).

$$P_{2\text{ of }2} \approx 2\lambda_1\lambda_2 T t_D \qquad (1)$$

Where $IFSD$ = average fleet IFSD rate, events per 1000 engine flight hours
T = total flight time
t_D = mean diversion time
λ_1 = cruise power IFSD rate, events per engine flight hour
λ_2 = maximum continuous power IFSD rate, events per engine flight hour
a = cruise power IFSD scalar used to obtain λ_1 from the IFSD rate
b = maximum continuous power IFSD scalar used to obtain λ_2 from the IFSD rate

$$P_{2\text{ of }2} \approx 2 \cdot \frac{a}{u} \cdot \frac{b}{V} \cdot L \cdot \overline{D} \cdot IFSD^2 \qquad (2)$$

Where $\overline{D}$ = mean diversion distance
$IFSD$ = average fleet IFSD rate, events per unit distance
L = flight distance
V = cruise true airspeed
u = one engine inoperative cruise true airspeed

Note: Engine manufacturers, General Electric, Pratt & Whitney, and Rolls-Royce independently assessed the effect of thrust rating on the IFSD rate of an engine. Their conclusion was that the IFSD rate during cruise was 0.5 times as great as the average IFSD rate and the IFSD rate under maximum continuous power was 1.75 times as great as the average. However, the ARAC team decided to use 0.5 for the cruise power IFSD scalar, ***a***, and 2.0 for the maximum continuous power IFSD scalar, ***b***. These scalars are the same as those used for earlier ETOPS deliberations for the development of the ICAO and IL-20 equations.

The FAA proposal was used only in a comparative role. Thus, the constants on the right side of equation 2 disappear and the parameters L, $\overline{D}$, and $IFSD$ remain as shown in equation 3.

$$EEI = L_1 \cdot \overline{D}_1 \cdot IFSD_1^{\,2} = L_2 \cdot \overline{D}_2 \cdot IFSD_2^{\,2} \qquad (3)$$

The FAA concluded from the relationship given in equation 3 that reducing the IFSD rate from 0.02 to 0.01 allowed an increase of two in the flight length and mean diversion distance for the fleet with the 0.01 IFSD rate. (Since the EEI is used in a comparative role, the units may be returned to the more familiar time units if desired). This implication would allow a twin engine airplane to operate without restriction as to diversion distance up to the distance traveled in still air in 10 hours flying time with one engine inoperative.

The FAA also noted that if IFSD were held constant in equation 3 the result would be equation 4.

$$L_1 \cdot \overline{D_1} = L_2 \cdot \overline{D_2} \qquad (4)$$

The FAA further noted that the products in this equation represent an area or risk "foot print" of the flight. From this relationship it can be shown that the route to a destination with the lower maximum diversion distance may not necessarily be the lower risk route. A north Pacific route was given as an example where going from a standard 180 minute ETOPS route to a route with a maximum diversion time of 207 minutes actually resulted in lower total distance and a lower mean diversion distance, hence a lower risk route from the perspective of independent engine failures.

IFSD Rate Summary

Several different mathematical representations for allowable risk versus engine failure rate were compared. Each showed that an engine failure rate on the order of 0.01 per 1000 engine flight hours was adequate to allow unlimited diversion time from an independent engine failure perspective. A summary is given in Table 1.

IFSD Rate Summary
Required Average IFSD rates

ETOPS Div Time tmax (Rule Time)	ETOPS Div Time (Ave *)	ICAO (1)	FAA AC 120-42A 207 min Policy (2)	JAA IL #20 (3)	Relative Risk Baseline 0.05 (Linear) (4)	Relative Risk Baseline 0.02 (SQRT) (5)	FAA ETOPS Exposure Index EEI Constant (6)	Manufacturer NPA Phased Mission Analysis (7)
1	0.95	0.066		0.036	0.100	0.035	0.026	0.023
2	1.80	0.046	0.050	0.025	0.050	0.024	0.019	0.017
3	2.55	0.038	0.020	0.021	0.033	0.020	0.016	0.014
3.45	2.85	0.035	0.019	0.019	0.029	0.019	0.015	0.013
4	3.20	0.033		0.018	0.025	0.017	0.014	0.013
5	3.75	0.029		0.016	0.020	0.015	0.013	0.012
6	4.20	0.027		0.015	0.017	0.014	0.013	0.011
7	4.55	0.025		0.014	0.014	0.013	0.012	0.010
8	4.80	0.023		0.013	0.013	0.012	0.012	0.010
9	4.95	0.022		0.012	0.011	0.012	0.012	0.010
10	5.00	0.021		0.011	0.010	0.011	0.011	0.010

Table 1. Track Length, Flight Duration, T = 20 hours

*** Average ETOPS Diversion Time is defined for a trapezoidal flight profile as $t_{max}*(T-t_{max})/T$**

Although ETOPS has been considered to be a twin engine airplane issue because of the requirements of 14CFR 121.161, the ARAC team decided that the same level of safety should be assessed for three and four engine airplanes as well. This was done for the independent engine failure issue by exploring the probability equations for each airplane configuration. The basis to be used for the diversion was discussed at length, and it was concluded that the following scenarios would be assessed. A diversion after a single engine failure followed by two subsequent engine failures for the three engine airplane, and a diversion after two engines had failed followed by a single engine failure for the four engine airplane. Both scenarios were evaluated for a 20 hour track length duration and a maximum diversion time of 10 hours. The resulting required IFSD rates were 0.2 for the three engine airplane and 0.1 for the four engine airplane.

Equation (5a) is general and may be used to determine the probability of multiple engine power loss for any number of engines per airplane where the airplane diverts after the first engine failure. Equation (5b) expresses the mean diversion time, t_D, for a triangular or trapezoidal mission profile used for most FAA evaluations of ETOPS missions. A more useful arrangement of Equation (5a) is given in Equation(6). For a triangular or trapezoidal mission profile, use Equation (5b) for t_D in Equation (6).

$$P_F \approx nC_{n-1,k}a\lambda^{k+1}(bt_D)^k \text{ per flight hour} \qquad (5a)$$

$$t_D = \frac{t_{\max}}{T}(T - t_{\max}) \qquad (5b)$$

$$\text{IFSD} = 1000\lambda \leq \sqrt[k+1]{\frac{P_{Goal}}{nC_{n-1,k}a(bt_D)^k}} \cdot 1000 \text{ per flight hour} \qquad (6)$$

Where
$C_{n-1,k}$ = the number of combinations of n-1 things taken k at a time
P_{Goal} = probability goal, usually 10^{-9}
T = total flight time, hours
a = cruise power IFSD scalar
b = maximum continuous power IFSD scalar
k = number of engines to lose power during diversion
n = number of engines per airplane
t_{max} = Maximum Diversion Allowance, hours
λ = average fleet IFSD rate, events per flight hour

Note: The definition of mean diversion time, t_D, presented above is based on a simple triangular or trapezoidal mission profile. This is consistent with the way the FAA has interpreted the mission profile for ETOPS routes in the past. In the future, consideration should be given to using the actual mean diversion time. Great circle route equations and coordinates for alternate airports allow quick calculation of any flight path, and thence, the mean diversion time.

The logic for the probability of failure and goal IFSD rate for a special case in which a four-engine airplane is allowed to fly on after a single engine failure with a diversion required after the second engine failure is as follows:

The probability of arriving at any point in time along the flight path with all but one engine operating (exactly one engine failed) is given by,

$$P_{\text{Exactly 1 of 4}} = 4(1-\lambda_1 t)^3 \lambda_1 t \qquad (7a)$$

And, the probability of one of the remaining three engines failing in the next moment is given by,

$$\frac{d}{dt} P_{Exactly\,1\,of\,3} = \frac{d}{dt}[3(1-\lambda_3 t)^2 \lambda_3 t] \approx 3\lambda_3 \qquad (7b)$$

λ_3 is used here because it is assumed that the engines will be operating at some power between cruise and Maximum Continuous Power when one engine is inoperative.

Further, the probability of at least one of the two remaining engines failing in the time that it takes to divert from that point in time to the nearest suitable airport is given by,

$$P_{\text{At least 1 of 2}} = 2\lambda_2 g(t) \qquad (7c),$$

where *g(t)*is the diversion time as a function of time along the flight track.

The per flight probability of multiple engine power loss due to independent causes, P_F, may be obtained by integrating the product of equations (7a) through (7c) over the duration of the flight. This step is shown in equation (8a).

$$\begin{aligned} P_F &= \int_0^T 4(1-\lambda_1 t)^3 \lambda_1 t 3\lambda_3 2\lambda_2 g(t)dt \\ &= 24\lambda_1\lambda_2\lambda_3 \int_0^T (1-\lambda_1 t)^3 t g(t)dt \\ &\approx 24\lambda_1\lambda_2\lambda_3 \int_0^T t g(t)dt \qquad (8a) \end{aligned}$$

The following substitutions will allow integration of equation (8a) by parts:

$$u = t,\ du = dt,\ \text{and}\ dv = g(t)dt,\ v = \int g(t)dt$$

Noting that v is the area under the curve, *g(t)*, we may deduce without loss of generality that v may be represented by tt_D, where t_D is the mean value of *g(t)* over the interval of the integration. Thus, continuing the integration we have,

$$uv = ttt_D,\ \text{and} \int vdu = \int tt_D dt = \frac{t^2}{2}t_D,\ \text{which yields}$$

$$\left[t^2 t_D - \frac{t^2}{2}t_D\right]_0^T = T^2 t_D - \frac{T^2}{2}t_D = \frac{T^2}{2}t_D$$

Substituting the results of this integration into equation (8a) gives,

$$P_F \approx 12\lambda_1\lambda_2\lambda_3T^2t_D \text{ per airplane flight} \qquad (8b)$$

Converting equation (8b) to flight hours and substituting the fleet average engine failure rate, λ, for the individual power level λ's produces equation (9). For this case the scalar for λ_3 is assumed to be the average of scalars *a* and *b*.

$$P_F \approx Cab\frac{(a+b)}{2}\lambda^3Tt_D \text{ per flight hour} \qquad (9)$$

Equation (10) may be used to determine the required IFSD rate for any P_{Goal}.

$$\text{IFSD} = 1000\lambda \le \sqrt{\frac{P_{Goal}}{Cab\frac{(a+b)}{2}Tt_D}} \cdot 1000 \qquad (10)$$

Table 2 presents the required Average IFSD rates needed to meet Extremely Improbable Risk (1 X 10^{-9} per flight hour) for two, three, and four-engine airplanes. Maximum Diversion Allowance = 10 hours, Total flight time = 20 hours, and rates are IFSD events per 1000 Engine Hours.

Table 2. IFSD Rate Comparison.

n	k	$C_{n-1,k}$ or C	P_F for IFSD rate = 0.01	Equivalent Risk IFSD rates
2	1	1	1.0E-09	0.01
3	2	1	2.0E-13	0.17
4	2	3	8.0E-13	0.11
4*	1	12	1.5E-12	0.09

* Four engine airplane special case for flying on after a single engine failure until a second engine fails.

An IFSD rate of .01/1000 hours reduces the probability of complete loss of thrust due to independent failures to an acceptable level for the two-engine airplane. To put this fact in perspective, it is not reasonable to expect that the two independently caused in-flight shutdowns, which might occur during the entire life of a typical two-engine transport airplane, would occur on the same flight.

Very high engine reliability required for twin-engine ETOPS airplanes, coupled with enhanced engine maintenance training, and vigilant operational procedures result in the risk of total power loss being maintained at acceptably low levels. Likewise three and four engine airplanes have benefited from common design practices by the manufacturers of modern turbo-fan engines regardless of the number of engines installed on the airplane. Similarly, best practices and lessons learned on ETOPS airplanes over the past 15 years have resulted in improved maintenance, training, and operations by the air carriers and operators thus reducing the risk of both independent cause and common cause failures events without regard to the number of engines on the airplane. The result is a safer fleet for all.

AC 33.100, "Turbine Engine Eligibility for Early ETOPS"

1. PURPOSE. This advisory circular (AC) provides guidance and acceptable methods, but not the only methods, that may be used to demonstrate compliance with the eligibility requirements for turbine engines with Section 33.100 ExTended OPerationS (ETOPS) of the Federal Aviation Regulations, Title 14 of the Code of Federal Regulations. Although this AC does refer to regulatory requirements that are mandatory, this AC is not, in itself, mandatory. This AC neither changes any regulatory requirements nor authorizes changes in or deviations from the regulatory requirements.

2. BACKGROUND.

This effort was selected as an Aviation Rulemaking Advisory Committee (ARAC) project.

This AC provides information and guidance that addresses Federal Aviation Administration (FAA) type certification standards for aircraft turbine engines for ETOPS without the requisite amount of service experience traditionally expected for an FAA finding of suitability.

3. DEFINITIONS

"Early" ETOPS. This means applicants seeking an FAA finding of ETOPS eligibility for their engine for an identified airframe application (airframe/engine application) in advance of the requisite amount of in-service experience hours.

Engine - a basic engine system certified by the FAA under 14 CFR Part 33

Propulsion system - an engine, nacelle, cowling, inlet, strut, etc. package that mounts to the airplane (wing or fuselage)

Note 1: engine and propulsion system are discussed within the AC in the context of a 3000 cycle test for the engine and propulsion system

Note 2: additional definitions are contained in Table 1 that pertain directly to the contents of Table 1.

4. GENERAL

There are three means by which an engine can be found eligible for ETOPS;

In-service experience (14 CFR 33.100 does not apply. This AC 33.100 does not apply)

Test and analysis without in-service experience (14 CFR 33.100 and all related Sections apply. This AC 33.100 applies)

The third approach is a combination of in-service experience and analysis and test. This AC does not apply directly to the combination method; however, it is expected that an applicant will use the guidance provided to propose means of compliance for which the FAA will be able to make an ETOPS eligibility finding.

Regulation section 33.100 identifies the test and analysis requirements for applicants seeking ETOPS type design eligibility for turbine engines for use in Part 25 transport category aircraft without the in-service experience required by 14 CFR 25, Appendix L (paragraph L25.4(a). This has been referred to variously as "early ETOPS", as "ETOPS out of the box", and as "ETOPS at EIS (entry-into-service)". For consistency within this AC and the regulation, this will be referred to as "early ETOPS".

The guidance provided in this AC applies to either of the following two situations:

The engine has already been found to be in compliance with the airworthiness standards contained in Part 33 of the Federal Aviation Regulations (14 CFR 33), or,

The engine is undergoing simultaneous Part 33 certification and early ETOPS eligibility assessment by the FAA.

5. GUIDANCE FOR 14CFR 33.100 EARLY ETOPS ELIGIBILITY:

a. The rule states….. *Each applicant seeking engine type design eligibility for ExTendedOPerationS (ETOPS) for an engine to be installed in a twin-engine ETOPS airplane that does not have the service experience required by 14 CFR 25, Appendix L (para L.25, 4a.):*

(a) Must:

have a design quality process to assure that features of the engine minimize the occurrence of failures, malfunctions, or maintenance errors that could result in loss of thrust control, inflight shutdown, or other power loss, and,

show that the design features of the engine have addressed problems that have been shown to result in loss of thrust control, inflight shutdown, or other power loss, when compared to that applicant's other relevant type design approvals provided within the past ten years. Applicant's with less than ten years commercial engine service experience may show equivalent experience in a manner acceptable to the Administrator.

Guidance:

a.1. This part of the rule is intended to require that the engine designers use their best design practices, including all their corporate knowledge, skills and lessons learned, to eliminate from the design all known failures, malfunctions, or design related maintenance errors experienced in other relevant FAA certified engines early in service that are especially relevant to ETOPS, such as loss of thrust control, inflight shutdown, or other power loss events. "Ten years" as used in the rule, is considered to be the time frame relevant to design/manufacture evolving technology for which the applicant must show that problems especially relevant to ETOPS have been addressed in the design for which early ETOPS eligibility is sought. For example, an early 1980's certified engine with a relatively lower level of reliability, would not be appropriate to use in an applicant's experience base of lessons learned for compliance with sec. 33.100(a)2 for an engine certified in year 2000; a much better experience base would be engines certified from 1990, which as an industry group have very good reliability. The intent is to continuously build upon the improved reliability seen in today's engines into even higher levels of reliability. The FAA recognizes that even with the advances in design and manufacturing technology, methods, process capability and reliability; loss of thrust control, inflight shutdown, or other power loss events can occur. The intent of the industry is to minimize the likelihood of an engine and propulsion system caused diversion, and to protect the safety of the airplane in the event of a diversion.

a.2. Compliance with the rule may be shown by evidence that the applicant's design quality assurance process has demonstrated the capability to:

eliminate causes of engine failures, malfunctions, and design related maintenance problems known to have occurred from the applicant's past 10 years commercial engine experience base.

preclude the recurrence of that cause, and,

show that he has addressed those causes to prevent recurrence in that specific design.

The applicant's process and design features must address all failures, malfunctions, and maintenance problems that could affect ETOPS even if they occurred on taxi; for example, if such an event could have occurred in flight. This is necessarily directed to events that have actually occurred, that while not having been experienced in take-off, climb, cruise, decent, approach, or landing phases of a flight, are required by the rule to be addressed - if they could occur in flight and are especially relevant to ETOPS, such as loss of thrust control, inflight shutdown, or other power loss events.

a.3. The rule applies to new engines ("new" addressed later in this AC) for engines intended for early ETOPS twin-engine aircraft.

b. In para. (b) the rule states……*Must subject the engine plus all associated components covered by the engine's Type Certificate to the testing required by Part 33.90(b).*

Prior to and following completion of the test, the engine must be subjected to a calibration test at sea level conditions. Any change in thrust characteristics at the conclusion of the test must be within certified limits.

At the conclusion of the test the engine must be:

Visually inspected according to the applicant's on-wing inspection recommendations and limits.

Completely disassembled. Engine hardware must be inspected taking into account the lessons learned from the applicant's design quality process from Section 33.100(a)1., and in accordance with the service limits submitted in compliance with section 33.4. Engine hardware shall not show distress to the extent that could result in loss of thrust control, inflight shutdown, or other power loss. Such hardware distress must have corrective action by way of design changes, maintenance instructions, or operational procedures. The type and frequency of hardware distress that occurs during the engine test must be consistent with the type and frequency of hardware distress that would be expected to occur on ETOPS eligible engines, or any non-ETOPS derivative engines of this type. Additional analysis and/or tests may be required to satisfy this requirement.

Guidance:

b.1. This part of the rule requires a test for new engines for early ETOPS for twin-engine aircraft. The intent of this test is to subject a new engine to an accelerated exposure of simulated service operation typical of in-service operation for which ETOPS eligibility is sought. The test will expose the engine to possible failure modes not normally expected under the normal certification requirements of Part 33. The test duration of 3000 cycles is based on the historical fact that the vast majority of problems that have resulted in engine in-flight shutdowns have occurred within 3000 cycles on airplane/engine combinations found eligible by the FAA for ETOPS. Additionally, high time engines in service might be expected to accumulate 3000 cycles over the first two years of service experience. Successful completion of this test will provide confidence that the new engine has the requisite reliability for early ETOPS.

b.2. A 3000 cycle test was first mandated for the early ETOPS approval of the twin-engine powered B777 under the FAA Early ETOPS Special Conditions (25-ANM-84) for the reason discussed above. However, prior to and subsequent to the certification of the B777, other aircraft types with new engines, and other derivative engine types have successfully demonstrated the requisite level of reliability for ETOPS under normal certification procedures, or with some other test-service demonstrations, by very well qualified and experienced engine applicants. However, the FAA considers that new twin-engine airplane-engine combinations, based on the successful service introduction of the B777 are required to undergo a 3000 cycle ground test to demonstrate the requisite level of reliability for early ETOPS eligibility.

b.3. For purposes of assessing early ETOPS eligibility only, a new engine is defined as an engine which has new architecture in comparison with other engines of similar type designed by that applicant. An engine with changes to its architecture relative to another certified design may be required to conduct the early ETOPS test if the system dynamics of the engine are considered a major change from previous experience. In addition, an engine which is installed into a new aircraft application or installation (new for the engine), may require the test to demonstrate reliability of the propulsion system. Further guidance follows and is provided in Table 1, relative to engine architecture and installation technical considerations.

b.4. A good technical understanding of the engine architecture and the aircraft installation is necessary to determine to what extent, if any, the test content requirements of 33.90(b) is required for derivative engines and for major changes to certified engines for early ETOPS eligibility. The content of the test will be dependent upon the level of change from the baseline engine considering the vibratory characteristics of the airframe/engine combination. This means technically assessing the effects of possible overall mechanical size/stiffness changes, structural (engine backbone) changes, changes in the dynamics of the engine, changes to bearing spacing and arrangement, changes to the number of structural frames, changes to the engine mounting arrangement to the aircraft, changes to the number of compression/turbine stages, and changes to the diameter/mass of the fan - to the extent that these contribute to the system dynamics or vibratory signature of the engine.

b.5. The technical basis for the test applicability to engines intended for twin-engine airplanes rather than 3 and 4 engine airplanes is that the allowable IFSD rate to maintain safe flight throughout the diversion, and landing, is an order of magnitude greater for a tri- or quad-engine aircraft compared to a twin-engine aircraft, assuming equivalent risk and flight duration. This also assumes that the aircraft can maintain safe flight throughout the diversion and land with one engine inoperative.

TABLE 1 – Engine Architecture and Installation Considerations for 3000 Cycle Testing

Case	**Type Certificate**	**Ratings & Limitations**	**Basic engine architecture[2]**	**Engine 3000 cycle test per Part 33.90(b)**
A1. New engine[1]	New	New	New	Yes
A2. Derivative engine[4] with major changes, may also be a new aircraft application/ installation	Could be new or Amended	Changed/increased	Could change, but not extensively (to a lesser degree than A1)	Yes, for the propulsion system of the aircraft, if engine system dynamics[3] change relative to baseline such that the original test is not valid
B1. Model change[5] – engine with minor or major changes	Amended	May involve no change, or lower ratings, or some thrust growth	No change	If ratings increase, and if base model has not accumulated 250,000 engine-hours, some fractional portion of the test is required to validate the new ratings to the same extent as the original test.
B2. Model change – engine in a new aircraft installation (new for it)	Amended	B1 above applies	No change	Same as B1, except a 3000 cycle test may be required for propulsion system of the aircraft
C. Major design changes[6]	No change to existing TC	No change	Same	No

Definitions:

1. New engine = new engine architecture (see note 2), or an engine for which an application for a new type certificate is made in accordance with 14 CFR Part 21.15 or 21.19 (unless an FAA approved 3000 cycle test has been completed on an engine of relevant architecture).
2. Engine architecture = overall mechanical size/stiffness, static structure (backbone), dynamics of engine, bearing arrangement, number of structural frames, mounting arrangement to aircraft, number of compression/turbine stages, size/diameter of the fan – to the extent that these contribute to the system dynamics (see note 3, sometimes referred to as the “signature”) of the engine

3. System dynamics (signature) of engine = vibratory response and system criticals as a function of engine mass/stiffness/rotor speeds, and engine/aircraft mount/strut mass/stiffness
4. Derivative engine = could involve changes to the engine architecture that it was developed from, and usually (not always) a new/different aircraft
5. Model change = amended TC; same TC as original engine usually with ratings and limitations changes, replaces original model engine, may be a new aircraft application
6. Major design change = product improvement/fix to engine, or change at customer request

b.6. The 3000 cycle test engine system and hardware acceptance criteria:

1. Prior to the test the engine is subject to a calibration test. The purpose of this test is to establish the engine's rated thrust characteristics at sea level static conditions for comparison to a calibration test conducted at the end of the test. Rated thrust characteristics, at speed and temperature, must be within certified limits at the conclusion of the test.
2. Visual inspection at test completion - this may be done periodically throughout the duration of the test to satisfy other requirements, such as to simulate on-wing borescope inspections, and for assessing the health of the engine, but this is required by the rule at the conclusion of the test in order to establish a correlation between assembled engine visual appearance and piece part inspection following disassembly. Assembled engine hardware visual condition is required to meet the applicant's recommended visual inspection and borescope limits.
3. Hardware condition disassembled - hardware inspection is to be accomplished taking into account the lessons learned from the applicant's design quality process (ref. Section 33.100(a)(1) and in accordance with the applicant's recommended Instructions for Continued Airworthiness (ICA) submitted in compliance with Section 33.4. Applicable ICA for this inspection includes the engine maintenance manual or section, and the engine overhaul manual or section, as identified in Appendix A to Part 33. Hardware condition that could result in loss of thrust control, inflight shutdown, or other power loss events is unacceptable. Hardware condition not serviceable per the applicant's ICA is not necessarily cause for failure to comply with the rule, if it can be shown by the applicant that the hardware condition would not result in events especially relevant to ETOPS such as loss of thrust control, inflight shutdown, or other power loss, had it remained assembled in the engine. It's important to distinguish between hardware condition in hand, available to see visually, that would not be recommended for re-installation, and hardware with the same condition installed in the engine. Normal wear or deterioration associated with the test time and cycles accumulated in the test is not necessarily cause for failure of the test if it can be shown by the applicant that the hardware condition is benign; no hardware distress or impending failure conditions are evident that would affect the safety of operation or result in an event especially relevant to ETOPS such as loss of thrust control, inflight shutdown, or other power loss. However, considerable

engineering judgment and experience needs to be employed in assessing and understanding the engine hardware condition especially for unusual or unexpected outcomes. For example, experience has shown that apparently minor hardware "telltale" signs not even to the category of "distress" could be a precursor to a potentially major hardware condition should the engine be subjected to more operational time/cycles, or a broader range of operating conditions. In addition, hardware distress caused by disassembly of the engine is not cause for failure of the test, if potential damage is covered by the applicant's ICA. Parts considered expendable at disassembly, to be replaced with new parts at re-assembly, are also not cause for failure of the test. Hardware condition or distress not addressed in the applicant's ICA, but found as a result of the test, need to be added to the applicant's ICA.

b.7. Using standard certification procedures, the FAA will make a determination of suitability and approve the applicant's proposed hardware corrective action found as a result of the 3000 cycle test.

6. GUIDANCE RELATIVE TO NEW 14CFR 33.90(b):

a. The rule states…… *Sec. 33.90 Initial maintenance inspection and early ETOPS tests Each engine, except engines being certificated through amendment to an existing type certificate or through supplemental type certificate procedures, must complete one of the following tests on an engine that substantially conforms to the final type design:*

Paragraph (a) of the rule states…. *(a) Initial maintenance inspection test: An approved test run that simulates the conditions in which the engine is expected to operate in service, including typical start-stop cycles, to establish when the initial maintenance inspection is required.*

Paragraph (a) of the rule is unchanged, except for reordering of words to accommodate the addition of Paragraph (b). Refer to AC 33-2B for guidance relative to new Section 33.90(a)

Paragraph (b) of the rule states….. *(b) Combined initial maintenance inspection and early ETOPS tests. When required by part 33.100, approved tests of simulated ETOPS service operation and vibration endurance that consists of:*

1. 3,000 representative service start-stop cycles (take-off, climb, cruise, descent, approach, landing and thrust reverse), plus three simulated diversions at maximum continuous thrust for the maximum diversion time for which ETOPS eligibility is sought. These diversions are to be approximately evenly distributed over the cyclic duration of the test, with the last diversion to be conducted within 100 cycles of the completion of the test.

This test must be run with the high speed and low speed main engine rotors unbalanced to generate at least 90 percent of the applicant's recommended maintenance vibration levels. For engines with three main engine rotors the intermediate speed rotor must be unbalanced to generate at least 90 percent of the applicant's recommended acceptance vibration level. The vibration level shall be defined as the peak level seen during a slow accel/decel of the engine across the operating speed range. Conduct the vibe survey at periodic intervals throughout the 3000 cycle test. The average value of the peak vibe level observed in the vibe surveys must meet the 90% minimum requirement. Minor adjustments in the rotor unbalance (up or down) may be necessary as the test progresses, in order to meet the required average vibration level requirement. Alternatively, to a method acceptable to the Administrator, an applicant may modify their test to accommodate a vibration level marginally less than 90% or greater than 100% of the vibration level required in lieu of adjusting rotor unbalance as the test progresses.

2. Each one hertz bandwidth of the high speed rotor service start-stop cycle speed range (take-off, climb, cruise, descent, approach, landing and thrust reverse) must be subjected to 3x106 vibration cycles. An applicant may conduct the test in any rotor speed step increment up to 200 rpm as long as the service start-stop cycle speed range is covered. For a 200 rpm step the corresponding vibration cycle count is to be 10 million cycles. In addition, each one hertz bandwidth of the high speed rotor transient operational speed range between flight idle and cruise must be subjected to 3x105 vibration cycles. An applicant may conduct the test in any rotor speed step increment up to 200 rpm as long as the transient service speed range is covered. For a 200 rpm step the corresponding vibration cycle count is to be 1 million cycles.

3. If the applicant chooses, it is permissible to conduct a complete visual inspection according to the applicant's on-wing inspection recommendations and limits, at an interval during the 3000 cycle test equivalent to an IMI test conducted to 33.90(a), in order to show compliance with the applicable requirements and obtain type approval, in advance of the completion of the full 3000 cycle test required by Section 33.90(b). Following inspection acceptable to the Administrator, the 3000 cycle test will be resumed to fulfill the requirements of this section and 14 CFR 33.100(b).

Guidance:
a.1. The test requirement in the rule applies to new engines, for installation/application in an ETOPS twin-engine airplane, in lieu of in-service experience, as discussed earlier. The test may be conducted in any suitable ground level static or altitude test facility/test cell of the applicant's choosing available for FAA inspection/test witnessing, as required.

a.2. The content of the test depends on the intended mission and operation of the aircraft for which approval of the engine is sought with the following guidance:

"Representative" service start-stop cycles as used in the rule means a representative mix of full rated, and de-rated missions that represent typical operations expected in the first two years of service. The test start-stop cycles should include the following flight profile segments: ground idle, take-off, climb/cruise, minimum idle, approach idle, and thrust reverse, which represent expected utilization of the airplane. The mix of rated thrust should include the maximum rated thrust, the minimum full rated thrust (if different than maximum rated thrust), and a de-rate of the minimum full rated thrust. By operating the engine from the maximum rated thrust to the minimum rated thrust, plus de-rate, the engine will be subjected to the full operating range expected for the airplane during the first two years of operation. The test conditions are to include typical engine bleed extraction (aircraft bleeds, anti-ice bleed, etc.), and power extraction (hydraulic loads, electrical loads, etc.) expected during typical phases of flight operation. Approximately one-third of the 3000 cycles should be operated with the anti-ice bleeds active (if air bleed anti-ice systems are used). In developing the start-stop cycles, significant integration is required with the airframe applicant to ensure that the correct mission, thrust mix, bleeds, and extractions are properly defined.

"Simulated diversions" as used in the rule means to conduct three simulated diversions to the maximum diversion time (minutes) for which early ETOPS eligibility is sought at maximum continuous rated power. The simulated flight diversions are to include typical engine bleed extraction (aircraft bleeds, anti-ice bleed, etc.), and power extraction (hydraulic loads, electrical loads, etc.) expected during a diversion. The simulated diversions should be approximately-equally spaced out during the 3000 cycle engine test with the last simulated diversion to be performed within the last 100 cycles of the 3000 cycle test. An applicant will typically conduct the simulated maximum continuous rated power diversions to the maximum ETOPS single engine diversion time sought (examples: 180 minutes, 240 minutes, 270 minutes, etc.). The applicant should consider future operational service needs in choosing the ETOPS diversion test time to be run in this test.

The engine's low speed and high speed main rotors are to be imbalanced to induce vibratory excitation equivalent to at least 90% of the applicant's recommended field service maintenance vibration level(s) to account for potential service-use imbalance for the duration of the endurance test. The intermediate rotor of a three spool engine is to be imbalanced to at least 90% of the applicant's recommended production acceptance level to account for nearly the maximum potential vibratory level for new engines shipped from production for the duration of the test. These rotor unbalance levels are to be maintained to these levels for the duration of the 3000 cycles of testing, unless the applicant proposes, and the FAA accepts, a modification to the test due to vibration levels above or below the range specified in the rule. The severity of the test is considered far in excess of the time/cycles duration in which an engine would remain on-wing in service at these vibratory excitation levels, therefore this test in total, is a much more severe simulation of operation than a new engine is expected to experience in early service. The target value when imbalancing the engine rotors is 100% of the associated vibration levels, the 90% number as used above represents the minimum average vibration level throughout the duration of the test. The vibration level shall be defined as the peak level seen during a slow accel/decel (typically 2 minutes up, two minutes down) of the engine across the operating speed range. The applicant shall conduct the vibe surveys at periodic intervals (typically 5-10, approximately evenly spaced) throughout the 3000 cycle test. The average value of the peak vibe levels observed in the vibe surveys must meet the 90% minimum requirement. This guidance material assumes that the slow accel/decel vibration survey is representative of the vibratory response of the engine during the 3000 cycle test and typical service operation. If not representative, another method acceptable to the Administrator may be proposed by the applicant.

Minor adjustments in the rotor unbalance (up or down) may be necessary during the test , in order to meet the required average vibration level requirement. Alternatively, using an analytical approach acceptable to the Administrator, an applicant may modify their test start-stop cyclic content (but at least 3000 cycles must be run) or the number of cycles per rpm step (up or down) to accommodate a vibration level that is marginally (just a few percentage points) below 90% or above 100% of the vibration level required in order to preclude the necessity of a disassembly and rebuild cycle to adjust rotor unbalance to achieve the required level of vibration.

The engine will be exposed to a stair step vibration test at one hertz (60 rpm) steps of the high speed rotor's operating range for the equivalent of 3x106 cycles for steady state speed points representing take-off, climb, cruise, descent, approach, landing and thrust reverse, and 3x105 cycles for transient speed points in the transient speed range between flight idle and cruise. A maximum 200 rpm step size may be run with the accumulation of 10 million (107) cycles for each steady state speed and 1 million (106) cycles for each transient speed step.

a.3. The intent of this testing is not to duplicate or repeat a demonstration of the cyclic content and duration of the engine endurance test as required by Part 33.87, rather to 1) simulate typical steady state and transient field service operation, and 2) simulate the extent of time that the engine will operate at maximum continuous power for the longest diversion time in an ETOPS scenario, both at a level of engine vibration that exceeds expected service operation. For transient engine speeds in the range between flight idle and cruise, conducting the testing at 3x105 cycles per hertz is equivalent to running that portion of the test at 67% of the recommended maintenance level rather than 100%. For example, for an engine whose recommended maintenance level is twice the production acceptance level, the engine will be tested at 1.33 times acceptance level in this speed range rather than at about 2 times the acceptance level. This is considered to be sufficient to simulate any likely operation of the engine in this speed range since engine thrust level is not a set point typically between flight idle and cruise thrust.

a.4. Part 33.90(b), for a new engine, is intended to both, establish when the initial maintenance inspection is required (Part 33.90(a)), and to show readiness for early ETOPS. This rule allows the applicant, to conduct a test program on one engine to demonstrate compliance to both regulatory objectives. If the applicant chooses, it is permissible to conduct a complete borescope visual inspection (ref. paragraph b.6., the 3,000 cycle test, engine system and hardware acceptance criteria, subparagraph 2, above) of the engine at an interval during the 3000 cycle test equivalent to an IMI test conducted to 33.90(a), in order to show compliance and obtain Part 33 certification, in advance of the completion of the full 3000 cycle test and an FAA finding of ETOPS eligibility. An applicant may need to take this approach in order to deliver compliance engines for an airplane flight test program. In this case, it is necessary for the applicant to disassemble the engine and conduct module inspection to complete the IMI requirement prior to entry into service.

7. GUIDANCE RELATIVE TO 14 CFR 33, Appendix A, A33.3 Content (new) **subparagraph(c):**

The rule states… *(c) ETOPS unique requirements. For engines to be installed in twin-engine ETOPS airplanes, procedures for an engine condition monitoring process, for twin engine ETOPS airplanes only, must be defined and validated for ETOPS type design eligibility. The engine condition monitoring process must be able to determine, pre-flight, if an engine is no longer capable of providing, within certified engine operating limits, the maximum thrust required for a single engine diversion. The effects of additional engine loading demands (e.g., anti-ice, electrical), which may be required during an engine inoperative diversion must be accounted for.*

Guidance:

It is intended that the applicant for engines for a twin-engine ETOPS airplane define and validate a process for operators to determine, prior to flight, when adequate thrust is not available for safe flight during a single engine diversion and landing.

Advisory Circular 120-XX, "Extended Operations (ETOPS)"

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APPENDICES

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Appendix 5 ETOPS Approval Beyond 180 minutes- Two-Engine Airplanes
Appendix 6 ETOPS Approval Beyond 240 minutes- Two-Engine Airplanes
Appendix 7 ETOPS Beyond 180 Minutes Approval - Airplanes with More Than Two Engines

1. PURPOSE
This Advisory Circular (AC) states an acceptable means but not the only means of obtaining operational approval under 14 CFR 121.161 to conduct Extended Operations (ETOPS). Operations with two-engine airplanes may be authorized over a route that contains a point farther than 60 minutes flying time from an adequate airport at an approved one engine inoperative cruise speed under standard conditions in still air. Operations with airplanes with more than two engines may be authorized over a route that contains a point farther than 180 minutes flying time from an adequate airport at an approved one engine inoperative cruise speed under standard conditions in still air. This AC also provides guidance for obtaining authorization to conduct operations in polar areas.

2. CANCELLATION
AC 120-42A, Extended Range Operation With Two-Engine Airplanes, dated December 30, 1988, EPL95-1, 138-Minute ETOPS Operational Approval Criteria, dated December 19, 1994 and EPL20-1, 207-Minute ETOPS Operational Approval Criteria, dated March 21, 2000 are canceled.

3. RELATED 14 CFR 121 SECTIONS
14 CFR 121.7, 121.97, 121.99, 121.106, 121.135, 121.161, 121.191. 121.197, 121.373, 121.410, 121.415, 121.565, 121.624, 121.625, 121.631, 121.633, 121.646, 121.687, 121.689, 121.703, 121.704, 121.705 and 121, Appendix N.

4. DEFINITIONS

In addition to the 14 CFR 1 and 121 definitions applicable to ETOPS, the definitions in this section apply within the context of this AC with respect to ETOPS.

Adequate Airport

1. For the purposes of those sections of 14 CFR 121 applicable to ETOPS, an adequate airport is an airport found by the Administrator to be equivalent to the provisions of 14 CFR 139, Subpart D safety requirements, excluding aircraft rescue and fire fighting service.
2. For the purposes of 14 CFR 121, an adequate airport is an airport that meets the landing performance requirements of 14 CFR 121 .197
3. For the purposes of ETOPS, military airports that are active and operational, and meet the landing performance requirements of 14CFR 121.197, are considered to be adequate airports.

Configuration, Maintenance and Procedures (CMP) Standard Specific airframe/engine configuration minimum requirements including any special inspection, hardware life limits, Master Minimum Equipment List (MMEL) constraints and maintenance practices found necessary by the FAA to establish the suitability of that airframe/engine combination for ETOPS.

Equi-Time Point (ETP) A point on the route of flight where the flight time, considering wind, to each of two selected airports is equal.

ER An abbreviation used in the Master Minimum Equipment List (MMEL) and in the Minimum Equipment List (MEL) of some certificate holders to indicate ETOPS. As used in this AC, any ETOPS MEL/MMEL restrictions applicable to ETOPS.

ETOPS Dual Maintenance Maintenance actions performed on the same element of identical, but separate ETOPS maintenance significant systems, during the same routine or non-routine visit. This is to recognize and preclude common cause human failure modes without the proper verification process or operation test prior to ETOPS.

1) For turbine engine powered airplanes with two engines - A maintenance action performed on the same element of identical but separate ETOPS maintenance significant systems during the same routine or non-routine visit.

2) For turbine engine powered airplanes with more than two engines - A maintenance action performed on the same element of identical but separate ETOPS maintenance significant systems on 2 engines of a 3 engine aircraft, or more than 1 engine per side of a 4 engine aircraft during the same routine or non-routine visit.

ETOPS Alternate An airport listed in the certificate holder's operations specifications that meet the requirements of 14 CFR121.624 and the Rescue and Fire Fighting (RFF) requirements of 14 CFR121.106 designated in a dispatch / flight release that is planned for use while an airplane is en route to the destination during ETOPS if continued flight is inadvisable. (Note: This designation is a planning requirement. It does not in any way limit the decisions of the pilot in command during flight.) An ETOPS alternate must be an adequate airport with weather reports or forecasts or any combination thereof indicating that weather conditions are at or above operating minima specified in the certificate holder's operations specifications and with field condition reports indicating that a safe landing can be accomplished at the time of the intended operation. (from the earliest to the latest time of landing at that airport).

ETOPS Area of Operation

For turbine engine powered airplanes with two engines an area beyond 60 minutes from an adequate airport, or with more than two engines an area beyond 180 minutes from an adequate airport, and within the authorized ETOPS maximum diversion time approved for the operation being conducted, or an area designated by the Administrator as an area of ETOPS applicability. An ETOPS area of operation is calculated at an approved one-engine inoperative cruise speed under standard conditions in still air.

ETOPS Maintenance Significant System

1) A system for which the redundancy characteristics are directly linked to the number of engines.
2) A system that may affect the proper functioning of the engines to the extent that it could result in an in-flight shutdown or uncommanded loss of thrust.
3) A system, which contributes significantly to the safety of a diversion.

ETOPS Entry Point

For turbine engine powered airplanes the ETOPS entry point is the first point on the route of an authorized flight which is more than 60 minutes from an adequate airport for airplanes with two engines, or 180 minutes from an adequate airport for airplanes with more than two engines, or a point designated as an entry point in an area designated by the Administrator as an area of ETOPS applicability. The ETOPS entry point is calculated at an approved one-engine inoperative cruise speed under standard conditions in still air.

ETOPS Qualified Personnel Maintenance personnel that have completed the certificate holder's ETOPS training program
Extended Operations (ETOPS) An approved operation for turbine engine powered airplanes a portion of which is more than 60 minutes from an adequate airport for airplanes with two engines, or a portion of which is more than180 minutes from an adequate airport for airplanes with more than two engines, or an area designated by the Administrator as an area of ETOPS applicability. ETOPS is calculated on an approved one engine inoperative cruise speed under standard conditions in still air.
Flight by Flight Exception The application of a greater ETOPS maximum diversion authority under specific, limited circumstances, as defined in this AC, when a flight cannot be planned on the preferred route within an authorized lesser diversion time.
In-flight Shutdown (IFSD) When an engine ceases to function in flight and is shutdown, whether self-induced, crew initiated or caused by some other external influence (i.e., IFSD for all causes; for example: due to flameout, internal failure, crew-initiated shutoff, foreign object ingestion, icing, inability to obtain and/or control desired thrust, etc.)
Maximum Diversion Time For the purposes of ETOPS in 14 CFR 121.161 and related ETOPS regulations, maximum diversion time (e.g., 120, 180, 240, beyond 240 minutes) is the diversion time, under standard conditions in still air at one engine inoperative cruise speed (approved), as authorized by the Administrator.
One Engine Inoperative Cruise Speed (Approved) For the purposes of those sections of 14 CFR 121 applicable to ETOPS, one engine inoperative cruise speed is a speed within the certified operating limits of the airplane, selected by the certificate holder and approved by the FAA that is used for calculating fuel reserve requirements and the still air distance associated with the maximum approved one engine inoperative diversion distance for the flight.

Following areas are defined for the purposes of those sections of 14 CFR 121 applicable to ETOPS,
NOPAC The North Pacific ATS routes and adjacent airspace between Anchorage and Tokyo FIRs.

North Pacific Pacific Ocean areas north of 40oN latitudes including NOPAC ATS routes, and published PACOTS (Pacific organized track system) tracks between Japan & North America.
Polar Areas - North Pole The entire area north of 78º N latitude
South Pole The entire area south of 60º S latitude

Process For the purposes of this AC, a process is a series of steps or activities that are accomplished in a consistent manner to assure that a desired result is attained on an ongoing basis.
Proven Process For the purposes of this AC, a process is considered to be proven when the following elements are developed and implemented:

- Definition and documentation of process elements
- Definition of process related roles and responsibilities
- Procedures for validation of process or process elements;
  - Indications of process stability/reliability.
  - Parameters to validate process and monitor (measure) success.
  - Duration of necessary evaluation to validate process.
- Procedure for follow-up in-service monitoring to assure the process remains reliable and stable.

SATCOM Satellite communications

5. APPLICABILITY

This AC provides guidance to certificate holders applying for approval to conduct ETOPS. This Advisory Circular also provides guidance to certificate holders currently conducting such operations in resolving operational issues that arise.

6. DISCUSSION

General All airplanes operated under 14 CFR 121 are required to comply with 14 CFR 121 .161. This regulation imposes special requirements in order for a two-engine airplane to operate over a route that contains a point farther than 60 minutes flying time at an approved one-engine inoperative cruise speed in still air from an adequate airport and for an airplane with more than two engines to operate over a route that contains a point farther than 180 minutes flying time at an approved one-engine inoperative cruise speed in still air from an adequate airport. It is significant to note that this rule applies equally to airplanes operating over oceanic areas or routes entirely over land.

To conduct ETOPS, the specified airframe/engine combination must have been certificated to the airworthiness standards of transport category airplanes and must be approved for ETOPS .The certificate holder must be approved for ETOPS per 14 CFR 121. As with all other operations, a certificate holder requesting any route approval must show that it is able to satisfactorily conduct scheduled operations between each required airport other than that route or route segment. Operators must show that the facilities and services specified in 14 CFR 121 .97 through 121.107 for domestic and flag operators and 14 CFR 121 .113 through 121.127 for supplemental operators and commercial operators are available and adequate for the proposed operation.

Background Although originally evolving during the era of piston-engine airplanes, the requirements of 14 CFR 121 .161 were effective and flexible enough initially to accommodate the increased reliability of the turbine-powered airplanes. With the advent of a new generation of twin engine airplanes in the 1980s that had significant improvements in range, payload and reliability, a desire arose to take advantage of the capability of these airplanes and to establish conditions under which extended range operations with these airplanes could be conducted safely.

AC 120-42 in 1985 and AC120-42A in 1988 recognized the increasing reliability of turbojet engines and helped to establish type design and operational practices for safe and reliable long-range operations with two-engine airplanes. As the technology and reliability of twin engine airplanes continued to improve due, in a large measure, to the requirements of these documents, such operations became compatible with those long range operations typically associated with 3-4 engine airplanes. At the same time this technology brought twins to the arena of long range operations, the infrastructure to support such operations was changing. Political and funding priorities forced the closure or reduction in basic services of a number of airports, both military and civilian, in remote areas that historically had been used as diversion airports for routes over oceanic and/or desolate land areas. The increasing use of Polar flights, while creating economic benefits, has brought new challenges to the operation. This reduction in operational infrastructure began to significantly impact the viability of all long-range twin-engine operations under current regulations and likewise began to erode the basic safety net that long-range operations in three and four engine aircraft had relied upon. Due to these pressures and to the increasing commonality of all long-range operations, the data began to show that ETOPS requirements and processes are generally applicable to all long-range operations including those by three and four engine airplanes and would improve the safety and viability of all long range operations. The reliability and system architecture of modern twin engine airplanes, developed specifically to address the requirements of AC120-42A, have begun to meet or exceed the capabilities of current 3-4 engine long range airplanes and it was believed that all long range airplanes, regardless of the number of engines, needed a viable diversion airport in the case of onboard fire, medical emergency or catastrophic decompression. Ensuring availability of en route alternate airports, adequate fire fighting coverage at these airports, and fuel planning to account for depressurization are sound operational practices for all airplanes including three and four engine airplanes. Likewise, all airplane time critical systems should account for the maximum allowable diversion and worst-case scenarios. To address these issues, a reasonable approach was to demand that many of the ETOPS requirements, based on sound safety principals and successfully proven over many years of operations, should be applied to all long-range operations. 14 CFR 121.161 has now been changed to include airplanes with more than two engines in long range operations and as a result certain practices from these two engine ETOPS have been applied to all airplanes over such operations. Accordingly ETOPS, which was defined as ‘extended range operations with two engine airplanes,’ has been re-defined as ‘Extended Operations’ to enhance the safety and reliability of all long range operations and to include the operations of airplanes with more than two engines.

121.161 Historical Basis. 14 CFR 121.161 has an extensive historical basis, which began as early as 1936. The rule in effect in 1936 required the applicant to show, before obtaining approval for the operation, that intermediate fields, available for safe takeoff and landings, were located at least at 100-mile intervals along the proposed route. This restriction applied to all airplanes operating under this rule regardless of the terrain or area that was to be overflown. Throughout the evolution of the current 121.161 the following factors have remained constant:

- The rule has always applied to all areas of operation and has not been limited to overwater operation.
- Any additional restrictions imposed or, alternatively, any deviations granted to operate in excess of the basic requirements were based on a finding by the Administrator that adequate safety would be provided in the proposed operation and current levels of safety would be maintained when all factors were considered. This finding was never limited to engine reliability alone.
- The airports used in meeting the provisions of the rule must be adequate for the airplane used (i.e., available for safe landings and takeoff with the weights authorized)
- Adequate levels of safety within the operation are to be maintained. Operations over increasingly remote areas and the possibility of increased diversion lengths have a potentially negative impact on the safety of the diversion, and thus the operation as a whole. This potential increase in risk must be mitigated by application of appropriate compensatory measures.
- When considering the impact of increasing diversion time, it must be shown that the operation can be conducted at a level of reliability, which maintains an acceptable level of risk.

In June of 1985, responding to the industry's desire to take advantage of the increased reliability and capabilities of twins, the FAA issued AC120-42. This provided guidance on one means to obtain deviation authority from 14 CFR 121.161 and allow twins to operate on routes up to 120 minutes from an adequate airport after demonstration of specific levels of in-service experience and systems reliability. This Advisory Circular was amended in 1988 with the publication of AC120-42A, with operations of twin engine airplanes permitted up to 180 minutes from an adequate airport. Both of these documents encompassed the following precepts:

- Reliance on a two-fold approval; type design of the airframe/engine combination (AEC) and a concurrent operator approval.
- Risk, as measured by diversion length, must be mitigated by application of regulations reflecting current best practices, which addresses the technical build standards of ETOPS airplanes and their systems and the operational environment of such operations.
- ETOPS can be managed successfully, and the level of safety can be maintained, by up to date regulations that articulate quantifiable standards of reliability and experience.

The original guidance for extended range operations with two-engine airplanes in AC 120-42 allowed an increase up to 15 percent in the maximum diversion time of 120 minutes. This provision was eliminated with the release of the guidance in AC 120-42A providing for operations up to 180 minutes. Recognizing a need for ETOPS diversion authority between 120 and 180 minutes, the FAA reinstated the 138-minute provision by issuing policy letter EPL 95-1 in 1994. In March of 2000, at the request of the industry, the FAA issued ETOPS Policy Letter EPL-20-1, 207 minute ETOPS Operation Approval Criteria. This document provided a similar 15% increase in the 180-minute maximum diversion time and gave limited relief to ETOPS operators in the specific case of

Northern Pacific Operations. Among other factors, the FAA took the following into consideration during the development of this policy letter:

- The ETOPS concept had been successfully applied since 1985 and was now widely employed and well established.
- Precedence for operational extension of maximum diversion time by up to 15 percent existed.
- Allowing 207-minute ETOPS extension was not intended to encourage or support further closures of en route alternate airports.

Since the advent of the original 14 CFR 121.161, extended twin operations have been governed by this process of evolving and progressive rules, which have reflected the successful and ever-increasing experience of the industry. As capable as this body of rules has been in the past, it has become increasingly clear that a need existed to codify all the disparate documents into a single body of rules and to update the existing rules to reflect all the industry improvements such progress has used as it's basis.

7. CONCEPTS

Extended Operations

The ETOPS limit for twin since 1988 has been 180 minutes from an adequate airport at an approved one engine inoperative cruise speed under standard conditions in still air (excluding the limited authority in the North Pacific given under the 207 Minute Policy Letter of March 2000). Service experience has shown that although limited, this authority has been satisfactory to successfully support the vast majority of the world's current aviation routes. Those areas not supported within 180-minute diversion authority tend to be routes over remote areas of the world that are uniquely challenging to the operation. The additional operational challenges of these routes are equally demanding of all airplanes, regardless of the number of engines, and include such issues as extremes in terrain and meteorology, as well as limited navigation and communications infrastructure. Support of a necessary diversion and subsequent recovery in such areas demand added training, expertise and dedication from all operators. The development of Extended Operations requirements is intended to address all these issues. Even though for continuity with the current two engine operations the existing acronym ETOPS is retained, the ETOPS acronym has been re-defined and the concept has been expanded to also include all operations planned with their proposed flight plan at any point greater than 180 minutes from an adequate airport (at an approved one engine inoperative cruise speed under standard conditions in still air).

Because of the successful experience and application of the 180-minute ETOPS authority and the premise that increasing diversion length potentially increases risk, it is prudent to expect all operators to continue to flight plan to the minimum diversion authority necessary to operate efficiently on the planned route. For this reason it is reasonable to continue to demand that all ETOPS for two-engine airplanes be flight planned at 180-minute diversion authority and that such additional regulatory authority addressed in this document be based on specific needs in defined areas of operations and be used on an exception basis. Similarly, all ETOPS for three and four-engine airplanes should designate the nearest alternate, and be flight planned at 240-minute diversion authority. The difference in application between twins and airplanes with more than two engines reflect the difference in ETOPS threshold (60 min for twins versus 180 minutes for others), the perception that there are added dimensions to twin operations, and the tacit acknowledgement of the current interpretation of the engine failure requirements of 14 CFR 121.565.

Past progress and successes achieved in ETOPS have been due to the deliberate and limited step process of extending diversion lengths in response to improvements in type design and the operational environment. These incremental steps in operational authority are a natural progression of such a process. This is the justification and impetus for the expansion to the new 240-minute and beyond 240-minute ETOPS authority for twin engine airplanes. The step-by-step process codified within the original AC, carried out and extended in actual ETOPS since 1984 has proven the merits of ETOPS processes and current applications. It is likewise reasonable and realistic to assume that as experience is gained and practices refined at current levels of ETOPS, that the reliability and performance of the operation will continue to improve and the foregoing premises will be validated. Such a regulatory review process, requiring the highest standards of operational competency and dedication from successful applicants has been instrumental in providing and protecting the tremendous success of ETOPS, and has been the catalyst for expansion in both the flexibility and scope of twin operations. Application of these concepts for all operators (twins, tris and quads) will enhance the safety of their operations and benefit the industry.

Area of Operations. The authority to conduct twin-engine operations beyond 180 minutes from an enroute alternate was first addressed in the 207-minute Policy Letter issued in March 2000. This increased authority was granted to address specific operational concerns in a defined geographical area of operations. The requirements placed on the operation and the measures imposed on the operator to manage such an operation were consequently specific to such a limited environment. Consequently there was a significant level of confidence in its successful application. This process of limiting expanded ETOPS authority beyond 180 minutes (for twins) has been extended in the regulations and serves several purposes. The primary importance is the preclusion of an arbitrary use of diversion authority beyond that necessary to complete the operation safely and efficiently. Since it is accepted that increased diversion times potentially increase the risk of the operation, it should be a goal of all twin-engine flight planning to operate to the diversion time which provides the widest range of options in the event of a diversion while recognizing the economic benefits of a more direct route. Tying increased diversion authority to specific areas of operation accomplishes this goal while sufficiently addressing the operational needs of the industry. Likewise, this focus on specific needs and areas of operation does not add impetus to any perceived rationale for further degradation in the availability or capabilities of enroute alternates in remote areas of the world. Although the industry has no direct authority to effect the actions of sovereign nations, it is reasonable to base operations on the value of enroute alternate availability at reasonable diversion distances.

Risk Management and the Level of Safety. Since diversions are precipitated by abnormal events that either demand or warrant a deviation from the normal flight profile, it is accepted that both the airplane and it's passengers and crew will come under some level of stress during the diversion. Consequently it has been an accepted premise that increased diversion times increase the risk of the flight. In order to quantify such added risk, numerous risk models have been developed. In the development of AC120-42A, this risk model was a function of diversion length and propulsion system reliability or IFSD (Inflight shut down) and was "normalized" to the then established large fleet of twin civil transport turbo-fan powered airplanes. The desire was to maintain an equivalent level of safety to those operations as diversion length increased. Since this risk model had a direct relationship between diversion length and risk, the basic tenet for equivalent levels of safety was a more stringent IFSD requirement for increasing diversion authority. As a consequence of this emphasis on propulsion system reliability, the industry has been driven to build airplane engines of ever increasing reliability. This impetus has given the current fleet of modern twin-engine airplanes propulsion system reliabilities that were unachievable just fifteen years ago. Current service experience for the newest generation of engines developed for the world-wide ETOPS fleet has been remarkable and a credit to both the past ETOPS processes that have driven the industry to such levels and to the engine manufacturers themselves who have designed and built them. From the IFSD targets, for two engine airplanes, of .05/1000 engine hours for 120-minute ETOPS and .02/1000 engine hours for 180 minute ETOPS embodied in AC120-42A, this fleet currently has achieved an average in-flight shut down rate of less than approximately .01/1000 engine hours over the past few years. Such a level of engine reliability has accomplished two things.

The first is a realization that engine reliability is no longer the singular issue of focus for the safety and reliability of ETOPS. As the propulsion systems have achieved ever-increasing levels of reliability, other systems and operational issues have increased in their relevance to the level of safety and have become the primary focus in order to meet required levels of reliability to insure continued safe ETOPS operations. Secondly, the IFSD level of .01/1000 engine hours itself is representative of a level of reliability that, purely from a propulsion system measure, could be supportive of an increased diversion authority for a specific airframe/engine combination (AEC) when used in most commonly accepted risk models that are asymptotic in their solutions. Individual propulsion system abnormalities, operational considerations and the assumed reliability of other airplane systems then become significant issues that must be addressed in order to maintain a level of safety consistent with current operations. Since the adequacy of such requirements is derived only after credible experience is gained in the operation and their successful application is documented, it is prudent to refocus the regulatory environment on such other issues and to limit the present applications. As a result the regulations require a high level of reliability for flight critical systems.
Accepting this current level of engine reliability, as a standard for expanding twin's authority beyond 180 minutes is to acknowledge that engine reliability has improved to the point that mechanical failures of other flight critical systems have become equally significant. . Such a level of IFSD placed on the industry and maintained in the

operation, is the basis for increased diversion authority greater than those restrictions currently in place when all other issues are considered.

ETOPS Alternate. One of the distinguishing features of ETOPS operations is the concept of an en route alternate airport being available to which an airplane can divert after a single failure or failure combinations, which require a diversion. Whereas most airplanes operate in an environment where there is usually a choice of diversion airports available within a close proximity to the route of flight, the airplane conducting ETOPS may have only one alternate within a range dictated by the endurance of a particular airframe system (e.g., cargo fire suppressant) and therefore the approved maximum diversion time for that route. Therefore, it is important that any airport designated as an ETOPS alternate has the capabilities, services and facilities to safely support the airplane and its passengers and crew during the diversion. The weather conditions at the time of arrival should provide a high assurance that adequate visual references are available upon arrival at decision height (DH) or minimum descent altitude (MDA), and the surface wind conditions and corresponding runway surface conditions must be within acceptable limits to permit the approach and landing to be safely completed with an engine and/or systems inoperative.

At dispatch an enroute alternate must meet alternate weather requirements specified in the certificate holder's operations specifications. Due to the natural variability of weather conditions with time, as well as the need to determine the suitability of a particular enroute alternate prior to departure, such requirements are higher than the weather minimums required to initiate an instrument approach. This is necessary to assure that the instrument approach can be conducted safely if the flight must divert to an alternate airport. Additionally, since the visual reference necessary to safely complete an approach and landing is determined, among other things, by the accuracy with which the airplane can be controlled along the approach path by reference to instruments and the accuracy of the ground-based instrument aids, as well as the tasks the pilot is required to accomplish to maneuver the airplane so as to complete the landing, the weather minima for non-precision approaches are generally higher than for precision approaches.

While en route, the forecast weather for designated enroute alternates must remain at or above operating minima. This necessity provides ETOPS flights with the ability to resolve all diversion decisions successfully throughout the flight. The suitability of an en route alternate airport for an airplane which encounters a situation inflight which necessitates a diversion, including the provisions of 14 CFR 121.565, while en route on a ETOPS flight is based on a determination that the airport is still suitable for the circumstances, and the weather and field conditions at that airport will permit an instrument approach to be initiated and a landing completed.

In-service Experience. When AC 120-42 was first released in 1985, ETOPS was a new concept, requiring extensive in-service verification of capability to assure the concept was a logical approach. At that time, the FAA recognized that reduction in the in-service experience requirements or substitution of in-service experience on another airplane would be possible. Any reduction was to be based on "evaluation of the operator's ability and competence to achieve the necessary reliability for the particular airframe/engine combination in extended range operations". For example, a reduction in in-service experience might be considered for an operator who could show extensive in-service experience with a related engine on another airplane, which had achieved acceptable reliability. In-service experience in the airframe / engine combination likewise was a prerequisite under AC 120-42A to obtain FAA approval to conduct operations with two engine airplanes on routes up to 180 minutes from an adequate airport. In early 1990, the FAA also allowed operators to gain ETOPS operational approval through simulation/demonstration program. This provision addressed the need of some of the domestic operators who had no route where they could exercise 120-minute ETOPS authority but had a need to operate on a route that required 180 minutes ETOPS authority.

In 1995, based on ten years of actual operational data, the FAA developed specific guidance material (Accelerated ETOPS Operational Approval) which permitted conduct of such operations without accumulating in-service experience in the airframe /engine combination. Since then most ETOPS approvals have been granted under these guidelines. The following factors were considered in developing this guidance

- The basic ETOPS requirements for an operator to operate an airframe-engine combination for one (1) year, before being eligible for 120-minute ETOPS; and another one (1) year, at 120-minute ETOPS, before being granted 180-minute ETOPS approval remains as a benchmark and a legitimate methodology to obtain ETOPS authority.
- Such a specific requirement could create unnecessary economic and operational burdens on operators who had otherwise proven competence in their operation.
- The ETOPS concept had been successfully applied for close to a decade; ETOPS was widely employed and was well established. The number of ETOPS operations had increased dramatically and, in the North Atlantic, U.S. airlines had more twin-engine operations than three and four-engine operations.
- ETOPS operational data indicated that twin-engine airplanes had maintained a high degree of reliability due to implementation of specific maintenance, engineering and flight operation process-related requirements.
- Experience has indicated that compliance with the alternative processes of this new guidance has provided for successful ETOPS earlier than the standard time established in the basic AC.
- Previous experience with an airframe/engine combination before conducting ETOPS was not the sole critical factor in the safety of such operations. Compliance with ETOPS processes, however, was crucial in assuring high levels of reliability in twin-engine operations. Commitment to reliable ETOPS processes had been found to be a critical factor as well. Such commitment by operators had, in many cases, resulted in operation of twin engine airplanes at a mature level of reliability from the outset of operations. Such experience had validated the Administrator's discretion in AC120-42A to authorize early ETOPS.
- The purpose of this guidance was to establish the factors which the Director, Flight Standards Service might consider in permitting a reduction or substitution

of operators in-service experience requirement in granting ETOPS Operational Approval.

- The excellent propulsion-related safety record of two-engine airplanes has been maintained by the processes and operational requirements associated with ETOPS Type Design and Operational Approvals. Industry experience with such procedures and requirements has resulted in a body of processes that, when embraced by new ETOPS applicants, has enhanced their initial efforts and accelerated their learning curves in such operations. The record of success emphasizes the value of such processes and has proven that they were critical to an operator's success in ETOPS.
- Reduction or elimination of in-service experience requirements is possible when an operator fulfills the requirement that adequate and validated ETOPS processes were in place before ETOPS approval.
- The Accelerated ETOPS Operational Approval Program with reduced in-service experience did not imply that any reduction of existing levels of safety should be tolerated but rather acknowledged that an operator might be able to satisfy the objectives of this AC by a variety of means of demonstrating that operator's capability.
- ETOPS experience during the past decade clearly demonstrates that a firm commitment by the operator to establish proven ETOPS processes before the start of actual ETOPS and continued commitment throughout the life of the program is a significant factor in safe and reliable ETOPS.

Preclude and Protect. The whole premise of ETOPS has been to preclude a diversion and, if it were to occur, to have programs in place that protect the diversion. Under this concept, propulsion systems are designed and tested to assure an acceptable level of inflight shutdown; other airplane systems are designed and tested to ensure their reliability. Maintenance practices have been adopted to monitor the condition of the engines, take aggressive steps to resolve problems with airplane systems and engines, to minimize the potential for procedural and human errors and thereby preclude a diversion. However, despite the best design/testing, and maintenance practices, situations may occur which require an airplane to divert. Regardless of whether the diversion is for technical (airplane systems or engines related) or non-technical reasons, there must be a flight operations plan to protect that diversion. Such a plan may include ensuring that pilots are knowledgeable about diversion airport alternatives, weather conditions at the alternate, the ability to communicate with the airline's dispatch office and ATC, sufficient fuel to divert to the alternate, etc.

Under the 'preclude and protect' concept, various failure scenarios need to be considered. For example, during the design of the airplane, time-limited systems such as cargo compartment fire suppression/containment capability are considered. Fuel planning accounts for the possibility of decompression or the failure of an engine with considerations for icing. Best options under these scenarios are to be provided to the pilot before and during the flight.

In-service data shows that all airplanes, regardless of the number of engines, divert from time to time for various causes. Airplanes with more than two engines currently are operated in areas where there are a limited number of enroute airports, where the support infrastructure is marginal or with challenging weather conditions. All such operations should adopt the same ‘preclude and protect’ concept. If airplanes with more than two engines plan to operate in areas where en route airports are farther than 180 minutes or in north polar areas where weather conditions can be challenging at certain times of the year, these operations are required to meet the standards defined under ETOPS to ensure that all efforts are made to preclude a diversion and, if a diversion were to occur, procedures are in place to protect that diversion.

Operational Reliability/Systems Suitability. The safety of long-range operation (ETOPS) depends on the reliability of all airplane systems including the propulsion systems. Time limited systems such as cargo compartment fire suppression/containment capability are to be considered. An established and monitored program for the reliability of flight critical systems must be carried out.

Other factors that influence the safety and reliability of long-range operations may not be so obvious. Since the quality of maintenance and reliability programs can have an appreciable effect on the reliability of the propulsion system and the airframe systems required for long range operations, an assessment should be made of the proposed maintenance and reliability program's ability to maintain a satisfactory level of airplane systems reliability for the particular airframe/engine combination The flight operations and maintenance programs for long-range operations should be designed with an objective to preclude diversions and, if a diversion were to occur, to protect that diversion. ETOPS maintenance practices must also minimize the potential for procedural and human errors that could be detrimental to the safety of the operation.
Fuel planning must account for the possibility of a depressurization and/or failure of an engine with considerations for icing.

The conduct of long-range operations should consider the probability of occurrence of any condition that would reduce the capability of the airplane or the ability of the flight crew to cope with the adverse operating condition. System failures or malfunctions occurring during extended range operations could affect flight crew workload and procedures. Although the demands on the flight crew may increase, an assessment should be made to ensure that exceptional piloting skills or crew coordination are not required. Best options under all most likely scenarios are to be provided to the pilot before and during the flight.

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

8. ETOPS (Two-Engine Airplanes)
14 CFR 121 .161 states that no certificate holder may operate a turbine engine powered airplane over a route that contains a point farther than 60 minutes flying time from an adequate airport for airplanes with two engines (in still air at normal cruising speed with

one engine inoperative) or within an area designated by the Administrator as an area of ETOPS applicability unless approved by the Administrator in accordance with Appendix N of 14 CFR 121. The Polar areas are defined as an area of ETOPS applicability. ETOPS requirements are specified in the certificate holder's approved maintenance and operations programs. ETOPS must be authorized in the certificate holder's operations specifications and conducted in compliance with those sections of 14 CFR 121 applicable to ETOPS, including 14 CFR 121.633.

The Administrator may approve ETOPS operations for various areas of operation in accordance with the requirements and limitations specified in appendix N to 14 CFR 121. Operations within Polar Area (North & South Pole) and north of NOPAC (for ETOPS beyond 180 minutes only) must comply with the requirements of Section 12 of this AC.

All operators of airplanes with two engines operating on ETOPS routes must comply with all the operational and process requirements specified in the ETOPS regulations in 14CFR 121 as of the effective date of these regulations. However, it is not the intent of the FAA to require operators who, at the time of the effective date of these ETOPS rules, have the authority to operate on specific ETOPS routes, to re-apply for the specific route authority.

(a) 75 Minutes ETOPS

(1) Caribbean / Western Atlantic Area: Approvals may be granted to conduct ETOPS operations with maximum diversion times up to 75 minutes on Western Atlantic / Caribbean area routes without compliance with 14 CFR 121.161. The airframe-engine combination shall be reviewed by the Administrator to ensure the absence of factors that could prevent safe operations. The airframe engine combination need not be approved for ETOPS; however these operations must comply with the requirements of 14CFR 121.633. The operator shall employ an FAA approved maintenance program that specifically addresses factors significant to 75 minute ETOPS operations.

(2) Other Areas Approvals may be granted to conduct ETOPS operations with maximum diversion times up to 75 minutes on other than Western Atlantic / Caribbean area routes without compliance with 14 CFR 121.161. The airframe engine combination need not be approved for ETOPS; however it must comply with the requirements of 14CFR 121.633. The airframe-engine combination shall be reviewed by the Administrator ensure the absence of factors that could prevent safe operations. The operator shall employ an FAA approved operations and maintenance program that specifically addresses factors significant to 120 minute ETOPS operations. Minimum equipment list requirements for 120 minute extended range ("ER") operations apply to such operations.

(b) 90 minutes ETOPS (Micronesia). Approvals may be granted to conduct ETOPS operations with maximum diversion times up to 90 minutes on Micronesian area routes without compliance with 14 CFR 121.161. For such operations the airframe-engine combination must be type design approved for 120 minute ETOPS operations. The operator shall employ an FAA approved operations and maintenance program that specifically addresses factors significant to 120 minute ETOPS operations, except that a service check before departure of the return flight may not be required. Minimum equipment list requirements for 120 minute extended range ("ER") operations apply to such operations.

(c) 120 minutes. Approvals may be granted to conduct ETOPS operations with maximum diversion times up to 120 minutes. For such operations the airframe-engine combination must be ETOPS type design approved for 120 minutes. The operator shall employ an FAA approved operations and maintenance program that specifically addresses factors significant to 120 minute ETOPS operations. Minimum equipment list requirements for 120 minute extended range ("ER") operations apply to such operations.

(d) 138 Minutes.

(1) 120 Minute Exception, Approvals may be granted to conduct ETOPS operations with maximum diversion times up to 138 minutes. This authority is deemed to be an extension of already existing 120 minute ETOPS authority, and may only be exercised on a flight-by-flight exception basis. For such operations the airframe-engine combination must be type design approved for 120 minute ETOPS operations. In addition, airplane time-limited system capability may not be less than the authorized 138 minute diversion time in still air conditions at the approved one engine inoperative cruise speed plus a 15 minutes allowance for holding, approach and landing. The operator shall employ an FAA approved operations and maintenance program that specifically addresses factors significant to 138 minute ETOPS operations. Operators with 120 minute ETOPS authority but no 180 minute authority may apply to AFS-200 through their certificate holding district office (CHDO) for a modified MEL which satisfies the MMEL policy for system / component relief in ETOPS beyond 120 minutes. The operator shall submit for FAA approval a summary of revisions to training curricula for maintenance, dispatch and flight crew personnel which identifies differences between 138 minute ETOPS diversion authority and its previously approved 120 minute ETOPS diversion authority

(2) Operators with existing 180 minute ETOPS approval. Approvals may be granted to conduct ETOPS operations with maximum diversion times up to 138 minutes to operators with existing 180 minute ETOPS approval. This authority may be exercised on an unlimited basis. For such operations the airframe-engine combination must be type design approved for 180 minute ETOPS operations. The operator shall employ an FAA approved operations and maintenance program that specifically addresses factors significant to 138 minute ETOPS operations. Approved minimum equipment list provisions for "beyond 120 minutes ETOPS operations" apply to these operations. The operator shall submit for FAA approval a summary of revisions to training curricula for maintenance, dispatch and flight crew personnel which identifies differences between 138 minute ETOPS diversion authority and its previously approved 180 minute ETOPS diversion authority

(e) 180 Minutes. Approvals may be granted to conduct ETOPS operations with maximum diversion times up to 180 minutes. For such operations the airframe/engine combination must be ETOPS type design approved for 180 minute. The operator shall employ an FAA approved operations and maintenance program that specifically addresses factors significant to 180 minute ETOPS operations. Minimum equipment list provisions for "beyond 120 minutes ETOPS operations" apply to these operations.

(f) Greater than 180 minutes Approvals may be granted to operators with previous ETOPS experience to conduct ETOPS operations with maximum diversion times exceeding 180 minutes as specified in subsections 1, 2 ,3 and 4 of this section. Approvals may only be granted to operators with existing 180 minutes ETOPS approval on the airframe/engine combination listed in their application. In conducting all such operations, operators shall make every attempt to minimize diversion time along the preferred track and plan ETOPS operations at maximum diversion distances of 180 minutes or less. If conditions prevent the use of adequate airports within 180 minutes as ETOPS alternates, the route may be flown beyond 180 minutes authority subject to the requirements provided for the specific area of operations. In addition to the maintenance and flight operations programs, MEL limitations for 180 minute ETOPS apply. In addition, the Fuel Quantity Indicating System (FQIS), APU (including electrical and pneumatic supply to its designed capability), Autothrottle system, most reliable voice-based communications technology or data link capability, and one engine inoperative autoland capability shall be operative for dispatch. For company communications, on such operations, operators shall use the most reliable communications technology available as per 14 CFR 121.99(c). Operators shall inform the flight crew any time an aircraft is proposed for dispatch under this authority and make available the dispatch considerations requiring such operations.

(1) North Pacific On flight by flight exception basis, tracked by the operator, when an ETOPS alternate is not available within 180 minutes in the North Pacific area of operation, the nearest available ETOPS alternate must be specified within 207 minutes maximum diversion time. In conducting such operations the operator shall give ATS preferred track, if available, the first consideration. Application of this exception must be limited to circumstances such as political or military concern, volcanic activity, airport weather below dispatch requirements, temporary airport conditions and other weather related events. The airframe/engine combination shall be reviewed by the Administrator ensure the absence of factors that could prevent safe operations. All requirements specified in the Configuration Maintenance and Procedures (CMP) Standard for 180 minute ETOPS are applicable.

(2) Polar Area (North Pole) and North of NOPAC On a flight by flight exception basis, tracked by the operator, when an ETOPS alternate is not available within 180 minutes in the Polar Area (North Pole) or, North of the North Pacific Area of Operations, the nearest available ETOPS alternate must be specified within 240 minutes maximum diversion time. Application of this exception shall be limited to circumstances related to the weather extremes particular to this area of the world such as volcanic activity, extreme cold weather at en route airports, airport weather below dispatch requirements, temporary airport conditions and other weather related events. The criteria used by the operator to make determinations that extreme weather precludes the use of an airport must be established by the operator and accepted by the FAA and published in the operator's manual for the use of dispatchers and pilots. The airframe-engine combination must be ETOPS type design approved for 240 minutes. All requirements specified in the Configuration Maintenance and Procedures (CMP) Standard for 240 minute ETOPS are applicable to such operations.

(3) 240 minutes Area of Operations Approvals may be granted to operators with previous ETOPS experience and existing 180 minute ETOPS approval on the airframe engine combination listed in their application to conduct ETOPS operations with maximum diversion times up to 240 minutes on routes in the Pacific oceanic areas between the US west coast and Australia, New Zealand and Polynesia; south Atlantic oceanic areas; Indian Oceanic areas; oceanic areas between Australia and South America. The operator must designate the nearest available ETOPS alternate(s) along the planned route of flight. For such operations, the airframe/engine combination must be ETOPS type design approved for 240 minutes. All requirements specified in the Configuration Maintenance and Procedures (CMP) Standard for 240 minute ETOPS are applicable to such operations.

(4) Beyond 240 minutes Area of Operations- Approvals may be granted, to operators who have been operating in accordance with 180 min or greater ETOPS for 24 consecutive months of which at least 12 consecutive months shall be at 240 minutes ETOPS on the airframe-engine combination for which the authority is requested, to conduct ETOPS with maximum diversion times beyond 240 minutes between city pairs on routes in the Pacific oceanic areas between the US west coast and Australia, New Zealand and Polynesia; south Atlantic oceanic areas; Indian Oceanic areas; oceanic areas between Australia and South America. The operator must designate the nearest available ETOPS alternate(s) along the planned route of flight. For such operations, the airframe/engine combination must be ETOPS type design approved for the maximum authorized diversion time All requirements specified in the Configuration Maintenance and Procedures (CMP) Standard for beyond 240 minute ETOPS are applicable to such operations.

9. ETOPS AUTHORIZATIONS (Airplanes with More Than Two Engines)

14 CFR 121 .161 states that no certificate holder may operate a turbine engine powered airplane over a route that contains a point farther than 180 minutes flying time from an adequate airport for airplanes with more than two engines (in still air at normal cruising speed with one engine inoperative) or within an area designated by the Administrator as an area of ETOPS applicability unless approved by the Administrator in accordance with Appendix N. Polar area is defined as an area of ETOPS applicability. ETOPS requirements are specified in the certificate holder's approved maintenance and

operations programs. ETOPS must be authorized in the certificate holder's operations specifications and conducted in compliance with those sections of 14 CFR 121 applicable to ETOPS, including 14 CFR 121.633.

Approvals may be granted, for operations employing aircraft with more than 2 engines, to conduct ETOPS operations on a routine basis with maximum diversion times up to 240 minutes in any area of operations. For all such operations, the nearest available ETOPS alternate within 240 minutes diversion time (in still air at one engine inoperative speed) must be specified. If an ETOPS alternate is not available within 240 minutes, the nearest alternate ETOPS alternate must be specified. In either case the operator must designate the nearest available ETOPS alternate(s) along the planned route of flight. On all such operations, MEL limitations for ETOPS apply and in addition, the Fuel Quantity Indicating System (FQIS) and, if so equipped, SATCOM voice and SATCOM or HF Data Link must be operational. For company communications, on such operations, operators shall use the most reliable communications technology available per 14 CFR 121.99(c). For such operations, the airframe/engine combination must be ETOPS type design approved for the maximum authorized diversion time.

Operations within Polar Area (North & South Pole) and North of NOPAC (for ETOPS beyond 180 minutes only) must comply with the requirements of Section 12 of this AC.

All operators of airplanes with more than two engines operating on ETOPS routes must comply with all the operational and process requirements specified in the ETOPS regulations in 14CFR 121 as of the effective date of these regulations. However, it is not the intent of the FAA to require operators who, at the time of the effective date of these ETOPS rules, have the authority to operate on routes that under the new definition are classified as ETOPS routes, to re-apply for the specific route authority.

10. ETOPS MAINTENANCE PROGRAM/PROCEDURE

The operator must comply with the ETOPS maintenance requirements as specified in 14 CFR 121 .368 which are as follows:

(a) Configuration Maintenance and Procedures (CMP) document: The CMP establishes the baseline for each specific airframe/engine combination. Any subsequent configuration of or procedural changes necessary for continued safe ETOPS flights will be mandated through the Airworthiness Directive (AD) process. This may be accomplished by issuing an AD against the specific design problem, or by issuing an AD that requires incorporation of a revised baseline CMP.

No future CMP revisions will be issued that will identify updates or changes to existing ETOPS approved configurations. Revisions to the document may be issued to delete existing requirements, include alternate means of compliance or identify newly approved ETOPS configurations for a given airframe/engine combination, such as a new auxiliary power unit (APU) for that particular airplane, not enhancements to an existing, approved, ETOPS configuration.

(b) Maintenance Program: The basic maintenance program for the airplane being considered for ETOPS is the operator's continuous airworthiness maintenance program. This program should be reviewed by the FAA to ensure that all applicable CMP Maintenance requirements have been incorporated in an ETOPS supplement to the operator's maintenance program. This should include procedures to preclude identical maintenance actions from being applied to multiple similar elements in any ETOPS maintenance significant system during the same routine or non-routine maintenance visit. Servicing of fluids and gases is not considered multiple maintenance action. The maintenance program should ensure that the airborne equipment continues to be maintained at the level of performance and reliability necessary for ETOPS. Additionally:

(1) ETOPS related procedures, duties, and responsibilities, such as involvement of centralized maintenance control, should be clearly defined in the operators program.

(2) An ETOPS Pre-departure Service Check should be developed to verify that the airplane and certain significant items are airworthy and ETOPS capable. This check should be signed for by an ETOPS qualified maintenance person and accomplished prior to each scheduled ETOPS flight, except following irregular operations due to non-technical issues or when exempted in the operator's approved program. This check is not precluded by any other maintenance check.

For example, in areas where prevailing weather conditions are stable and generally do not approach extremes in temperature, wind, ceiling and visibility such as the Caribbean / Western Atlantic (75 minutes ETOPS) and Micronesia routes (90 minutes ETOPS) the service check may not be required for the return leg of an ETOPS flight.

(3) Log books should be reviewed to ensure proper MEL procedures; deferred items, maintenance checks and system verification procedures have been properly performed and documented as appropriate.

(4) System redundancy levels appropriate to ETOPS should be reflected in the MMEL. An operators MEL may be more restrictive than the MMEL considering the kind of ETOPS operation proposed and equipment and service issues unique to the operator.

(5) A list of fleet specific ETOPS maintenance significant systems should be approved by the Certificate Holding District Office (CHDO).

(6) If ETOPS dual maintenance actions are performed, use of adequate ground tests, separate maintenance technicians, Required Inspection Items procedures, restriction of the aircraft from ETOPS flights and/or a verification flight or other approved maintenance procedures may be used to verify the airworthiness of maintenance actions prior to ETOPS. This is to recognize and preclude common cause human failure modes.

(7) The operator should identify all tasks that must be signed for by ETOPS qualified personnel. ETOPS specific tasks should either:

a) Be identified on the operator's routine work forms and related instructions.
b) Parceled together and identified as an ETOPS package.

(8) Procedures and centralized control processes should be established which would preclude an airplane being dispatched for ETOPS flights after a propulsion system shut-down (on twin engine airplanes), significant primary airframe system failure, or significant adverse trends in system performance without appropriate corrective action having been taken. Confirmation of such action as being appropriate, in some cases, may require successful verification (as appropriate) prior to dispatch on an ETOPS flight

(c) Verification Procedure: Verification flights or actions (operation test, BITE, etc.) are accomplished to identify potential human factors or mechanical errors prior to an ETOPS flight. Verification flights may be conducted on revenue flights provided that verification of the affected system is completed prior to the ETOPS Entry Point. The operator should develop a verification program or procedures should be established to ensure corrective action following an engine shut-down (on twin engine airplanes), significant primary system failure, significant adverse trends, or any other prescribed event which require a verification flight or other actions, 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 operator's program. Primary systems determined to be significant, or conditions requiring verification actions should be described in the operator's ETOPS document.

(d) Engineering Modifications and Maintenance Program Considerations: Although these considerations are normally part of the operator's Continuing Airworthiness Program, the maintenance and reliability program may need to be supplemented in consideration of the special requirements of ETOPS. The following items, as part of the operator's program, will be reviewed to ensure that they are adequate for ETOPS:

(1) The operator shall provide to the CHDO all titles and numbers of all modifications, additions, and changes, which were made in order to substantiate the incorporation of the CMP standard in the airplanes, used in ETOPS operations.

(2) Following approval of the maintenance and training procedures established to qualify for ETOPS; substantial changes to those procedures should be submitted to the CHDO for approval 60 days before such changes can be adopted. The definition of substantial changes should be negotiated between the Operator and the CHDO.

(3) Approved modifications and inspections which would maintain the reliability objective for the propulsion and airframe systems as a consequence of Airworthiness Directives (AD) action should be implemented as directed.

(4) Other modifications, inspections, and procedures disseminated by the standard methods of manufacturer Service Bulletins, letters, or FAA guidance material should be considered for implementation. This would apply to both installed and spare parts.

(e) ETOPS Document: The operator should develop a document for use by personnel involved in ETOPS. This document need not be inclusive but should at least reference the maintenance program and other requirements described by this advisory circular, and clearly indicate where they are located in the operator's document system. All ETOPS requirements, including supportive programs, procedures, duties, and responsibilities, should be identified and subject to revision control. This document should be submitted to the CHDO for approval at least 60 days before implementation of ETOPS flights.

(f) Oil Consumption Program: The operator's engine/APU oil consumption program should reflect the manufacturer's recommendation and be sensitive to oil consumption trends. It should consider the amount of oil added at the departing ETOPS station with reference to the running average consumption (i.e., the monitoring should be continuous up to and including the oil added at the ETOPS departure station). If oil analysis is meaningful to this make and model, it should be included in the program. If the APU is required for ETOPS, it should be added to the oil consumption program.

(g) Engine Condition Monitoring: This program should describe the parameters to be monitored, method of data collection, and corrective action processes. The program should reflect the manufacturer's instructions and industry practices. The goal of this monitoring program should be to detect deterioration at an early stage, and to allow for corrective action before safe operation is affected. Engine limit margins should be maintained so that a prolonged single-engine diversion may be conducted without exceeding approved engine limits (e.g., rotor speeds, exhaust gas temperature) at all approved power levels and expected environmental conditions. Engine margins preserved through this program should account for the effects of additional engine loading demands (e.g., anti-ice, electrical), which may be required during IFSD flight phase associated with the diversion.

(h) Propulsion System Monitoring: As required by 14 CFR 121.368, the certificate holder must conduct an investigation into the cause of each in-flight shut down in conjunction with manufacturers and submit findings to the CHDO. If the CHDO determines that corrective action is necessary, the certificate holder must implement the corrective action.

Should the operator IFSD rate exceed the following values, an investigation into common cause effects or systemic errors must be conducted and findings must be submitted to the CHDO.

The following values are computed on a 12-month rolling average for two engine aircraft:

.05/1000 engine hours for ETOPS up to and including 120 minutes;

.03/1000 engine hours for ETOPS between 120 and including 180 min, and 207 min in North Pacific; and

.02/1000 engine hours for ETOPS above 180, except for 207 min in North Pacific.

The following values are computed on a 12-month rolling average for aircraft with more than two engines:

.2/1000 engine hours for 3-engine ETOPS; and

.1/1000 engine hours for 4-engine ETOPS.

The report of investigation shall be submitted within 30 days through the CHDO to the Director of Flight Standard for approval of corrective action taken, if necessary.

Causes of IFSD's or other engine/propulsion system problems may be associated with type design problems, and/or maintenance and operation procedures applied to the aircraft. It is very important to identify the root cause of events so that an indication of corrective action is available; a fundamental design problem requires an effective hardware (or software) final fix. Inspections may be satisfactory as interim solutions but longer term design solutions, i.e. terminating actions, are required if possible. Design problems can affect the whole fleet. An operator which experiences a type design related event, should not be operationally penalized by the Administrator for a problem that is design related and may not be of their making. However, maintenance or operational problems may be wholly, or partially, the responsibility of the Operator. If an Operator has an unacceptable IFSD rate risk attributed to maintenance or operational practices, then action carefully tailored to that Operator may be required.

An IFSD rate higher than the 12 month rolling average standard which occurs for a mature fleet after the commencement of ETOPS, or for a small fleet, may be due to the limited number of engine operating hours used as the denominator for the rate calculation; the effect being an IFSD jump well above the standard rate due to a single IFSD event. The underlying causes for such a jump in the rate will have to be considered by the Administrator's representative. On occasions, a particular event may also warrant corrective action implementation even though the overall IFSD rate is not being exceeded.

The 30 day reporting criterion is intended to assure that the operator provides timely notification of the status of an event investigation. The operator may or may not have root cause or terminating action at the end of the 30 day period, and further discussions with the FAA may be required after this period.

(i) Reliability Program: An ETOPS Reliability Program should be developed or the existing Reliability Program supplemented. This program should be designed with early identification and prevention of ETOPS related problems as the primary goal. The program should be event-oriented, and incorporate reporting procedures for critical events detrimental to ETOPS flights. This information should be readily available for use by the operator and the FAA to help establish that the reliability level is adequate, and to assess the operator's competence and capability to safely continue ETOPS operations.

The following 14 CFR s satisfy operator's requirements for ETOPS event reporting:
(1) 121.373 Continuing Analysis and Surveillance
(2) 121.703 Service Difficulty Reports (Operational)
(3) 121.704 Service Difficulty Reports (Structural)
(4) 121.705 Mechanical Interruption Summary Report

(j) Maintenance Training: The ETOPS Maintenance Training Program should focus on the special nature of ETOPS maintenance requirements. This program should be included in the accepted maintenance training curricula. The goal of this program is to ensure that all personnel involved in ETOPS are provided the necessary training so that the ETOPS maintenance requirements are properly accomplished. ETOPS qualified maintenance personnel are those who have successfully completed the operator's ETOPS training program and who have satisfactorily performed extended range tasks under the direct supervision of an FAA certificated maintenance person who has had previous experience with maintaining the particular make and model aircraft being utilized under the operator's maintenance program. For new aircraft introduction, the previous experience for training can be obtained from the manufacturers training program

(k) ETOPS Parts Control: The operator should develop a parts control program that ensures the proper parts and configurations are maintained for ETOPS. The program should include procedures to verify that the parts installed on ETOPS airplanes during parts borrowing or pooling arrangements, as well as those parts used after repair or overhaul, maintains the necessary ETOPS configuration.

(l) APU In-flight Start Reliability Program (if an APU is required for ETOPS): Each operator is to establish a monitoring program acceptable to the FAA CHDO to ensure that the APU will continue at a level of performance and reliability established by the manufacturer or the FAA. This monitoring program should include periodic sampling of APU in-flight starting capabilities. Operators with existing approved programs may continue under that authority. Sampling intervals may be adjusted according to system performance. The CHDO should periodically review the operator's APU in-flight start program data to ensure that the in-flight start reliability is maintained. Should the APU in-flight start rate drop below 95%, an investigation into common cause effects or systemic errors in procedures should be initiated.

The following criteria should be included in the operator's APU in-flight start validation program as part of their overall ETOPS maintenance program for each specific airframe/engine combination. APU in-flight starts should be made on flights of four hours or more when possible, subject to the following conditions:

(1) In-flight APU starts need not be performed on ETOPS flights, however, the APU must be in the ETOPS configuration in accordance with the applicable Configuration, Maintenance, and Procedures (CMP) document, in order for credit to be allowed.
(2) If in-flight APU starts are performed on an ETOPS flight, the start may be attempted on the return leg.
(3) The start attempt should be initiated before top of descent, or at such time that will ensure a two hour cold soak at altitude.
(4) If the APU fails to start on the first attempt, subsequent start attempts may be made within the limits of the airframe and APU manufacturer design specifications.

All occurrences of an ETOPS configured APU in-flight unsuccessful start attempt (which exceed the airframe and APU manufacturer design specifications) shall be reported to the Certificate Holding District Office (CHDO). All operationally required APU in-flight start failures occurring during actual ETOPS operations should be reported to the FAA. The final report should include corrective actions taken as well as the status of corrective action programs, fleet upgrades, etc.

(m) Continuing Surveillance: The fleet average IFSD rate for the specified airframe/engine combination will continue to be monitored. As with all other operations, the Certificate Holding District Office (CHDO) should also monitor all aspects of the ETOPS operations it has authorized, to ensure that the levels of reliability achieved in ETOPS operations remain at acceptable levels, and that the operation continues to be conducted safely. In the event that an acceptable level of reliability is not maintained, if significant adverse trends exists, or if critical deficiencies are detected in the type design or in the conduct of ETOPS operations, the CHDO should initiate a special evaluation, impose operational restrictions (if necessary), and ensure the operator adopts corrective actions in order to resolve the problems in a timely manner. The CHDO should alert the Type Certificate Office and the Aircraft Evaluation Group when problems associated with airplane design or operations are identified.

(n) Master Minimum Equipment List (MMEL): The manufacturer shall identify and the FAA shall approve all items required for ETOPS and include these items in the MMEL

11. FLIGHT OPERATIONS

(a) Airplane Performance Data No airplane may be dispatched on an ETOPS flight unless the performance data which meets the following requirements are made available to flight crewmembers and dispatchers

- Detailed one-engine inoperative performance data including fuel flow for standard and nonstandard atmospheric conditions and as a function of airspeed and power setting, where appropriate, covering:
  - Driftdown (includes net performance);
  - Cruise altitude coverage including 10,000ft
  - Holding;
  - Altitude capability (includes net performance); and
  - Missed approach.
- Detailed all-engine-operating performance data, including nominal fuel flow data, for standard and nonstandard atmospheric conditions and as a function of airspeed and power setting, where appropriate, covering:
  - Cruise (altitude coverage including 10,000 feet); and
  - Holding.
- Details of any other conditions relevant to ETOPS operations which can cause significant deterioration of performance, such as ice accumulation on the unprotected surfaces of the airplane, RAM Air Turbine (RAT) deployment, thrust reverser deployment.

(b) Operator Documentation and Training Programs

The FAA reviews in-service experience of critical and essential airplane systems. The review includes system reliability levels and individual event circumstances, including crew actions taken in response to equipment failures or loss of capabilities. The purpose of the review is to verify the adequacy of information provided to training programs and operating manuals. The aviation industry should provide in-service and reliability experience and participate in these reviews. The FAA will use the information resulting from these reviews to modify or update changes to flightcrew training programs, operating manuals, and checklists, as necessary.

(1) ETOPS Unique Requirements

The operator’s approved training program for ETOPS should include training that describes the unique aspects of ETOPS.

(2) Diversion Decision Making

Training to prepare flightcrews to evaluate probable propulsion and airframe systems failures should be conducted. The goal of this training should be to establish crew competency in dealing with the most probable operating contingencies.

The operator's ETOPS training program should provide and integrate training for flight crewmembers and dispatchers as applicable as listed below. A cross-section of these items will be periodically evaluated:

- Flight planning, including contingency data. i.e., engine failure, decompression, diversion equi-time point (ETP)
- Flight progress monitoring/Fuel Tracking
- Non-Normal Procedures

- Operational restrictions associated with dispatch under the MEL
- Abnormal and emergency procedures
- Systems failures and remaining airplane capability as it relates to the decision to divert or to continue
- Diversion
- Crew incapacitation
- If the loss of two main AC electrical power sources with no APU electrical source available results in significant degradation of instrumentation to either pilot, a simulated approach and missed approach with only an alternate power source available.

· Use of emergency equipment associated with ETOPS operations, including overwater and protective breathing equipment.
· Procedures to be followed in the event that there is a change in conditions at an en route alternate listed on the dispatch / flight release which would preclude safe approach and landing.
· Procedures to be followed in the event that there is a change in conditions at potential en route diversion airports which would preclude safe approach and landing.
· Understanding and effective use of approved additional or modified equipment required for ETOPS.
· Fuel Quantity Comparison. Fuel management procedures to be followed during the en route portion of the flight. These procedures should provide for an independent crosscheck of fuel quantity indicators. For example, fuel used subtracted from the total fuel load compared to indicated fuel remaining.
· Fuel Management: Accounting for discrepancies between planned fuel remaining and actual fuel remaining e.g., ETA ahead of or behind plan, gross weight and or altitude differences

(3) Passenger Recovery Plan

Training for flight crew and dispatcher role in the operator's passenger recovery plan must be provided per 14 CFR 121.415

(c) Check Airman Used in ETOPS

The operator should designate check airmen specifically for ETOPS. The objective of the ETOPS check airman program should be to ensure standardized flightcrew practices and procedures and also to emphasize the special nature of ETOPS. Only airmen with a demonstrated understanding of the unique requirements of ETOPS should be designated as a check airman.

(d) En Route Airport Information

In accordance with 14 CFR 121 .97, information on the operational capabilities of the airports designated by the operators for use as ETOPS alternates must be maintained by the operator in a current status.

The operator's program should provide flightcrews with current weather and operational information on all adequate airports in the ETOPS portion of the flight that are within the maximum diversion capability of the airplane on the planned route of flight. Appropriate facility information and other appropriate data concerning these airports should be provided to flight crews in clear, concise, user-friendly format for use when planning a diversion.

(e) Dispatch

Since ETOPS alternates serve a purpose different from that of a destination alternate and may be used in the event of diversion with an engine failure or loss of a primary airplane system, an airport should not be listed on the dispatch / flight release as an ETOPS alternate unless that airport's services and facilities are adequate for such a diversion. An operator of a two-engine airplane may exercise ETOPS beyond 180 minutes authority only if there are no ETOPS alternates that are within a 180 minute diversion distance from the planned route of flight. In addition, those adequate airports closest to the planned route of flight should be those first considered as ETOPS alternates.

(1)Flight Planning Limitation

The operator's ETOPS flight planning program must ensure that the planned route of flight remains within the ETOPS area of operation. As per 14 CFR 121.633:

(a) For ETOPS up to and including 180 minutes, the time required to fly the distance to the planned ETOPS alternate(s), at the one engine inoperative cruise speed(approved), in still air and standard day temperature, may not exceed the time specified in the Airplane Flight Manual for the airplanes most time limited system time minus 15 minutes

(b) For ETOPS beyond 180 minutes, the time required to fly the distance to the planned ETOPS alternate(s), at the all engines operating cruise speed, correcting for wind and temperature, may not exceed the time specified in the Airplane Flight Manual for the airplanes cargo fire suppression system time minus 15 minutes

(c) Except as provided in (b) above; for ETOPS beyond 180 minutes, the time required to fly the distance to the planned ETOPS alternate(s), at the approved one engine inoperative cruise speed, correcting for wind and temperature, may not exceed the time specified in the Airplane Flight Manual for the airplanes most time limited system time(except for cargo fire suppression) minus 15 minutes

Three and four-engine turbine powered airplanes not meeting the requirements of (b) above as of the effective date of 14 CFR 121.633 regulation may continue ETOPS operations for a period not to exceed 6 years from the effective date of this regulation.

(2)Landing Distance

For the runway expected to be used, the landing distance available as specified by the airport authority must be sufficient based on Airplane Flight Manual (AFM) landing performance data to meet the landing distance limitations specified in 14 CFR 121 .197. The altitude of the airport, wind conditions, runway surface conditions and airplane handling characteristics should be taken into account.

(3) Airport Rescue and Fire Fighting (RFF)

For dispatch, the minimum ICAO RFF category requirements are as follows:

For ETOPS up to 180 minutes:

- ETOPS alternates with category 4. In addition, although not required, there should be an attempt made to have at least one adequate airport with category 7 within 207 minutes of the planned route.

For 207 Minute ETOPS (airplanes with two engines only):

- ETOPS alternates with category 4. In addition, at least one adequate airport with category 7within 207 minutes of the planned route

For All Other ETOPS beyond 180 minutes:

- ETOPS alternates with category 7.

If the necessary equipment and personnel are not immediately available at the airport, a 30 minute response time is deemed adequate if the initial notification to respond can be initiated while the diverting aircraft is enroute. Such equipment must be available on arrival of the diverting airplane and remain as long as their services are needed.

(4) ETOPS Alternate Minima

A particular airport may be considered to be an ETOPS Alternate for flight planning and dispatch purposes if it meets the criteria below. Since, operations specifications alternate weather minima standards apply to all alternates, the following criteria is recommended for a typical certificate holder's operations specifications. An individual certificate holder's operations specification will reflect its current requirements.

APPROACH FACILITY CONFIGURATION[1]	ALTERNATE AIRPORT IFR WEATHER MINIMUM CEILING[2]	ALTERNATE AIRPORT IFR WEATHER MINIMUM VISIBILITY[3]
For airports with at least one operational navigational facility providing straight –in non-precision approach procedure, or Category I precision approach, or, when applicable, a circling maneuver from an instrument approach procedure.	Add 400 ft to the MDA or DH as applicable	Add 1 sm or 1600m to the landing minimum
For airports with at least two operational navigational facilities, each providing a straight in approach procedure to different suitable runways.	Add 200 ft to the higher DH or MDA of the two approaches used.	Add ½ sm or 800m* to the higher authorized landing minimum of the two approaches used.
One useable authorized category III ILS Instrument Approach Procedure (IAP)	200 feet	1/2 sm (800 m) or RVR 1800 feet (550 m)
One useable authorized category II ILS IAP	300 feet	3/4 sm (1200 m) or RVR 4000 (1200 m)

*For operations outside United States, due to variations in the international metric weather forecasting standards, 700m may be used in lieu of 800m

1 When determining the usability of an IAP, wind plus gust must be forecast within operating limits, including reduced visibility limits, and within the manufacturer's maximum demonstrated crosswind value.
2 Conditional forecast elements need not be considered, except that a PROB40 or TEMPO condition below the lowest applicable operating minima must be taken into account
3 When dispatching under the provisions of the MEL, those MEL limitations affecting instrument approach minima must be considered in determining ETOPS alternate minima.

(5) Fuel Supply
The operator must comply with the ETOPS alternate fuel supply as specified in 14 CFR 121 .646, which is as follows:
(a) No person may dispatch or release for flight or takeoff a turbine engine powered airplane with more than two engines more than 90 minutes (with all engines operating at cruising power) and less than 180 minutes (at the approved one engine inoperative cruise speed) from an adequate airport unless, considering wind and other weather conditions

(including icing), it has enough fuel, assuming a rapid decompression at the most critical point in terms of fuel supply followed by descent to a safe altitude in compliance with the oxygen supply requirements of 14 CFR 121.333, to fly to an adequate airport and conduct a normal approach and landing with enough fuel remaining to hold for 15 minutes at 1500 feet above field elevation.

(b) No person may dispatch or release for flight or takeoff a turbine powered airplane in ETOPS unless, considering wind and other weather conditions expected, it has enough fuel to satisfy (i) through (iv) below:

(i) Greater of :

(A) fuel sufficient to fly to an ETOPS alternate assuming a rapid decompression at the most critical point followed by descent to a safe altitude in compliance with the oxygen supply requirements of 14 CFR 121.333, or

(B) fuel sufficient to fly to an ETOPS alternate at the approved one engine inoperative cruise speed assuming a rapid decompression and a simultaneous engine failure at the most critical point followed by descent to a safe altitude in compliance with the oxygen supply requirements of 14 CFR 121.333, or,

(C) fuel sufficient to fly to an ETOPS alternate at the approved one engine inoperative cruise speed assuming an engine failure at the most critical point followed by descent to the one engine inoperative cruise altitude.

(ii) Upon reaching the alternate hold at 1500 ft above field elevation for 15 minutes and then conduct an instrument approach and land

(iii) Add a 5% wind speed factor (i.e., an increment to headwind or a decrement to tailwind) on the actual forecast wind used to calculate fuel in (i) above to account for any potential errors in wind forecasting. If a certificate holder is not using the actual forecast wind based on wind model acceptable to the FAA, allow 5% of the fuel required for (i) above, as reserve fuel to allow for errors in wind data. A wind aloft forecasting distributed worldwide by the World Area Forecast System (WAFS) is an example of a wind model acceptable to the FAA.

(iv) Compensate in (i) above for the greater of :

(A) the effect of airframe icing during 10 percent of the time during which icing is forecast (including ice accumulation on unprotected surfaces, and the fuel used by engine and wing anti-ice during this period). Unless a reliable icing forecast is available, icing may be presumed to occur when the total air temperature (TAT) at the approved one engine cruise speed is less than +10°C, or if the outside air temperature is between 0°C and -20°C with a relative humidity (RH) of 55% or greater.

(B) fuel for engine anti-ice, and if appropriate wing anti-ice for the entire time during which icing is forecast,

(c) Unless the certificate holder has a program established to monitor airplane in-service deterioration in cruise fuel burn performance and includes in fuel supply calculations fuel sufficient to compensate for any such deterioration, increase the fuel supply by 5% to account for deterioration in cruise fuel burn performance.

(d) If APU is a required power source, then its fuel consumption must be accounted for during the appropriate phases of flight.

In addition, the requirements in 14 CFR 121 .647 must be applied. In computing the ETOPS alternate fuel supply, advantage may be taken of driftdown computed at the approved one engine inoperative cruise speed. Accounting of wing anti-ice as in (b)(iv)(B) above may apply to some models of aircraft based on their characteristics and the manufacturer's recommended procedures.

(6) Communications

14 CFR 121 .99(a) includes a requirement for communications facilities providing reliable and rapid communications on routes and altitudes that may be used to ETOPS alternate airports.

14 CFR 121 .99(c) includes a requirement for voice communications. For all ETOPS operations beyond 180 minutes, the most reliable communication technology, voice based or data link must be installed. Where voice communication facilities are not available, and voice communication is not possible or is of poor quality, communications using alternative systems must be substituted.

(7) Dispatch / Flight Release

The following must be listed in the dispatch or flight release for all ETOPS per 14 CFR 121 .687:

- ETOPS alternates
- The authorized ETOPS diversion time under which the flight is dispatched.

The pilot in command should have access to the weather and status of services and facilities at all adequate airports with weather greater than approach minimums other than the designated ETOPS alternates along the planned route that could be used for diversion prior to accepting the release

f. En Route

(1) Pilot in Command Authority No part of this AC is to be interpreted as reducing the pilot in command's joint responsibility for determining that the flight can be safely conducted as planned prior to release. None of the guidance in this Advisory Circular may be interpreted in any way to prejudice or limit the final authority and responsibility of the pilot in command for the safe operation of the airplane.

(2) Potential Diversion Airports after Departure

After departure, designated ETOPS alternates must continue to meet the requirements of original dispatch, except that the weather must remain at or above operating minima. (14 CFR 121 .631(c)) The pilot and dispatcher are to monitor the airports within the ETOPS area of operation that could be used for diversion for deterioration in the weather and limitations in the availability of facilities and services that would render an airport unsuitable for landing in the event of a diversion. During the course of the flight, the flightcrew must be informed of significant changes in conditions at the designated ETOPS alternates, particularly those conditions that would render an airport unsuitable for landing and improvement in airport weather to conditions above operating minima.

Before an ETOPS flight proceeds beyond the ETOPS entry point, the weather from the earliest to latest time of arrival at the designated ETOPS alternates, as well as the landing distances, airport services, and facilities should be evaluated. If any conditions such as weather below landing minima are identified that would preclude a safe approach and landing, the pilot should be notified and an additional ETOPS alternate(s) selected where a safe approach and landing can be made. A revised flight plan should include information on the newly designated ETOPS alternates within the authorized area of operation. Information on the weather and capabilities (i.e., emergency response, approach aids, navigation facilities, airport infrastructure, etc) of potential ETOPS alternates in the authorized area of operations should be available to the pilot. The maximum diversion time determined by the newly selected ETOPS alternate(s) should not exceed the authorized ETOPS maximum diversion time that could have been applied at original dispatch.

(3) Engine Failure 14 CFR 121 .565 requires the pilot in command of a two engine airplane with one engine inoperative to land at the nearest suitable airport where, in the judgment of the pilot in command after considering all relevant factors, a safe landing can be made. The pilot in command should consider all relevant factors in determining the suitability of an airport. The following factors and others may be relevant in determining whether an airport is suitable or not:

- Airplane configuration / weight / systems status / fuel remaining
- Wind and weather conditions en route at the diversion altitude
- Minimum altitudes en route to the diversion airport
- Fuel burn to the diversion airport
- Airport nearby terrain, weather and wind
- Runways available and runway surface condition
- Approach navaids and lighting available
- RFFS at the diversion airport
- Facilities for passenger and crew disembarkation and accommodations
- Pilot's familiarity with the airport
- Information about the airport provided to the pilot by the certificate holder

When operating a two engine airplane with one engine inoperative, none of the following factors may be considered sufficient justification to fly beyond the nearest suitable airport:

- The fuel supply is sufficient to fly beyond the nearest suitable airport
- Passenger accommodation other than passenger safety
- Availability of maintenance / repair resource

If no more than one engine is shut down on an airplane that has three or more engines, the regulation (14 CFR 121.565) permits the pilot in command to fly beyond the nearest suitable airport in point of time if he determines that doing so is as safe as landing at the nearest suitable airport. In making a decision to fly beyond the nearest suitable airport, the pilot in command should consider all relevant factors and, in addition, consider the possible difficulties that may occur if flight is continued beyond the nearest suitable airport.

(4)System Failure / Partial Failure

During ETOPS, the limited availability of diversion airports and extended diversion distances require that the impact of a system failure or partial failure be carefully evaluated. This should include a careful assessment of remaining system and overall operational capability. Time permitting, full use should be made of the information available through the operator's dispatch function and a determination made by the pilot in command as to the plan for the safe continuation of the flight, that is, under the circumstances, whether it is safer to divert and land or to continue as planned.
If, as a result of reevaluating airplane systems, a change in flight plan is required, the pilot shall be provided revised flight plan information and an update of conditions, including weather conditions, at designated ETOPS alternates. Dispatch should advise the flight crew of additional airports on the planned route of flight that could be used for diversion. In no case may the maximum approved diversion authority of the operation be exceeded.

12. Polar Area (North & South Pole) and North of NOPAC (for ETOPS beyond 180 minutes only) Operations

The FAA has established a process that can be applied uniformly to all applicants for polar route authority. In addition some of these practices are also applicable to ETOPS operations beyond 180 minutes on North of NOPAC. That process is used to validate the operator's preparedness to conduct these operations.
This section documents the requirement for the operator to develop plans in preparation for all polar flights in the north and south polar areas and ETOPS operations beyond 180 minutes north of NOPAC, and identifies equipment and airplane configuration requirements.
Area Approval Operators are required to obtain FAA approval to conduct these operations and also obtain approval to operate in the area of magnetic unreliability. FAA approval is granted by amendment to the operator's operations specifications.
Requirements for Designating ETOPS Alternates Operators are expected to designate a set of alternate airports, such that one or more can reasonably be expected to be available in a variety of weather conditions. The flight must be able to make a safe landing and the airplane maneuvered off of the runway at the selected diversion airport. In the event of a disabled airplane following landing, the capability to move the disabled airplane must exist so as not to block the operation of any recovery airplane. In addition, those airports designated for use must be capable of protecting the safety of all personnel by being able to:

- Offload the passengers and crew in a safe manner during adverse weather conditions;
- Provide for the physiological needs of the passengers and crew for the duration of the stay at the diversion airport until safe evacuation, and;
- Be able to safely extract passengers and crew as soon as possible (execution and completion of the passenger recovery is expected as soon as possible within 48 hours following diversion).

For these operations, the passenger recovery plan discussed in Section 13 must include special consideration for the possibility of extreme cold weather, limited passenger facilities and the need to initiate passenger recovery without delay.

Fuel Freeze Strategy and Monitoring The operator may wish to develop a fuel freeze strategy and monitoring program in lieu of using the standard minimum fuel freeze temperatures for specific types of fuel used. In such cases, the operator's fuel freeze analysis and monitoring program for the airplane fuel load is subject to FAA approval. The operator should have procedures established that require coordination between maintenance, dispatch, and assigned flightcrew to convey the determined fuel freeze temperature of the fuel load on board the airplane.

Communication Capability The operator must have an effective voice communications and/or data link capability for all portions of the flight route. ATC communications require HF voice. Company communications may be accomplished using HF voice, HF data link, SATCOM voice or SATCOM data link. It is recognized that SATCOM may not be available for short periods during flight over the Poles, particularly when operating on Polar Routes 1 and 2. Communication capability with HF radios may also be affected during periods of solar flare activity. The operator needs to consider for each dispatched flight, the predicted solar flare activity and its effect on communications.

MEL Considerations. The operator will amend its MEL to reflect the items that must be operational for these operations. For polar operations, as a minimum all MEL restrictions for 180-minute ETOPS operations apply. Before receiving FAA authority to conduct these operations, the operator will amend its MEL for the following systems / equipment to indicate that they are required for dispatch:

- Fuel quantity indicating system (FQIS), including the fuel tank temperature indicating system
- APU, including electrical and pneumatic supply to its designed capability
- Autothrottle system
- Communication system(s) relied on by the flightcrew to satisfy the requirement for communication capability
- Expanded medical kit (AED)

Training. The operator must reflect the following training requirements in its approved training programs:

- QFE/QNH and meter/feet conversions: (required for flight crew and dispatcher training).
- Training requirements for fuel freeze. Maintenance, dispatch, and flightcrew training (special curriculum segments).
- General route-specific training on weather patterns
- Relevant aircraft system limitations e.g., fuel temperature limits.
- Maintenance role in providing airplane systems capability information to dispatch and flight crew to aid the PIC in diversion decision making.
- Crew training in the use of the cold weather anti-exposure suit.
- Dispatch and crew considerations during solar flare activity. The operator must be aware of the content of AC 120-52, Radiation Exposure of Operator Crewmembers and provide crew training as stated in AC 120-61, Crewmember Training on In-Flight Radiation Exposure.
- Training for flight crew and dispatcher role in the operator's passenger recovery plan must be provided

Long-range Crew Requirements The following long-range crew issues need to be addressed by the operator:

- Rest plan submitted to the POI for review.
- Multicrew flight proficiency issue needs to be addressed in the training program.
- The progression of PIC authority as designated by the operator.

Special Equipment for Polar Operations A minimum of two cold weather anti-exposure suits will be required to be on board, so that outside coordination at a diversion airport with extreme climatic conditions can be accomplished safely. A short term MEL relief for this item may be granted provided the operator has arranged ground support provisions for providing such protective clothing at alternate airports.
Validation Before Approval In order to receive authorization to conduct these operations, the operator will be required to conduct an FAA observed validation flight. As part of the validation, the operator will be required to exercise its reaction and recovery plan in the event of a diversion to one of its designated ETOPS alternates. Adequate and timely notification must be made to the FAA so that the coordination necessary to have an FAA inspector in place at the selected diversion airport can be made. The inspector will witness the effectiveness and adequacy of the following:

- Communications
- Coordination
- Facilities
- Accuracy of NOTAM and weather information
- Operability of ground equipment during the simulated diversion.

The exercise of the operator's reaction and recovery plan may be completed before the validation flight.
AFS-200 will give favorable consideration to a request by the operator, through the POI, to conduct the validation flight in a passenger revenue status only if the operator's reaction and recovery plan has been previously demonstrated to the satisfaction of the FAA.
If the operator elects to demonstrate its reaction and recovery plan as part of and during the validation flight, the flight cannot be conducted in a passenger revenue status. The carriage of cargo revenue is permissible in this case and is encouraged for airplane weight and balance purpose.

13. ETOPS APPLICATIONS (All Applications)

The unique nature of long range operations necessitates an evaluation of these operations to ensure that the operator's proposed programs are effective. To the extent that changes in the operator's continued airworthiness and operations program are required as a result of this evaluation, they are to be approved through the normal approval processes.
The FAA will review the operator's documentation and training programs to validate that they are appropriate for ETOPS. Each operator applying for ETOPS approval must demonstrate the ability to continuously maintain and operate the particular airframe systems and engine at levels of reliability appropriate for the intended operation. The operator must also show that it has trained its personnel to achieve competency in ETOPS. The operator must show compliance with the flight operations requirements (Section 11) and Maintenance requirements (Section 10) of this AC.
This section provides general guidance for all ETOPS applicants.

An ETOPS applicant of two-engine airplane for ETOPS up to 180 minutes may select the one of the following three application methods (Appendices 1to 3) best suited to the proposed operation:

Appendix 1 - In-service Experience
Appendix 2 - Simulation / Demonstration
Appendix 3 - Accelerated ETOPS

ETOPS (138 minute extension of 120 minute ETOPS) - Appendix 4
ETOPS (beyond 180 minutes) application for two-engine airplanes - Appendix 5
ETOPS (beyond 240 minutes) application for two-engine airplanes - Appendix 6
ETOPS (beyond 180 minutes) application for airplanes with more than two engines - Appendix 7

Operators applying for approval to operate in the Polar Regions and north of NOPAC (for ETOPS beyond 180 minutes only), also refer to guidance in Section 12 of this AC.
The FAA may require a validation flight as per Section 14(a). As per Section 14(b), the certificate holder's operations specification will be amended when an approval to conduct operations under 14 CFR 121 .161 is granted.

All operators of airplanes with two or more engines operating on ETOPS routes must comply with all the operational and process requirements specified in the ETOPS regulations in 14CFR 121 as of the effective date of these regulations. However, it is not the intent of the FAA to require operators who, at the time of the effective date of these ETOPS rules, have the authority to operate on specific ETOPS routes or routes that under the new definition are classified as ETOPS routes, to re-apply for the specific route authority.

ETOPS Area of Operations /Airplane Performance The altitudes, airspeeds used in establishing the ETOPS area of operations for each airframe-engine combination must be shown to permit compliance with the terrain and obstruction clearance requirements of 14 CFR 121 .191(c) and 14 CFR 121 .193, as applicable.
Weather Information System An operator should substantiate that the weather information system, which it utilizes, can be relied upon to forecast terminal and en route weather with a reasonable degree of accuracy and reliability in the proposed area(s) of operation. Such factors as staffing, dispatcher, training, sources of weather reports and forecasts and, when possible, a record of forecast reliability should be evaluated.
Minimum Equipment List (MEL) The operator is required to submit its MEL, in accordance with the MMEL, appropriate to the requested level of ETOPS. An operator's MEL may be more restrictive than the MMEL considering the kind of ETOPS proposed and the equipment and service problems unique to the operator. System redundancy levels appropriate to extended range operations should be reflected in the MMEL. Systems considered to have a fundamental influence on flight safety may include, but are not limited to the following:

- Electrical, including battery
- Hydraulic
- Pneumatic

- Flight instrumentation
- Fuel
- Flight control
- Ice protection
- Engine start and ignition
- Propulsion system instruments
- Navigation and communications
- Auxiliary power-units
- Air conditioning and pressurization
- Cargo fire suppression
- Emergency equipment and
- Any other equipment necessary for ETOPS

Communication and Navigation Facilities As per 14CFR121.99(a), the operator must demonstrate the availability of rapid and reliable two-way communication during diversion at anticipated diversion altitudes.

Passenger Recovery Plan The operator's formal passenger recovery plan for general application required under 14CFR 121.135 should be reviewed and determined to be adequate for the proposed ETOPS in the event of an unplanned diversion and deplanement. The recovery plan should address the safety and well being of passengers and crew at the diversion airport and include a plan to transfer the passengers and crew from that airport safely and without undue delay. The operator should be prepared to demonstrate the processes required to initiate and carry out its passenger recovery plan before ETOPS approval is granted The operator is expected to maintain the accuracy and completeness of its recovery plan.

Navigation

The applicant must show the availability of navigation facilities adequate for the operation, taking into account the navigation equipment installed on the airplane, the navigation accuracy necessary for the planned route and altitude of flight and the routes and altitudes to the airports the operator may designate as ETOPS alternates within the degree of accuracy required. Navigation facilities required to ensure a safe approach and landing must be available.

Communications

The operator must show the availability of communications services and facilities for ATC communications and communications with the dispatch office. For company communications, operators must use the most reliable voice-based communications technology available. Rapid and reliable ATC communications are determined by the facilities operated by ATC units in the areas of operations.

14. ETOPS VALIDATION AND APPROVAL

(a) ETOPS Validation Flight The operator should demonstrate, by means of an FAA-witnessed validation flight or flights using the specified airframe-engine combination, that it has the competence and capability to safely conduct and adequately support the intended operation. The Director, Flight Standards Service, will determine the conditions for each operator's validation flight(s) following a review on a case-by-case basis of the operator's experience and the proposed operation. This may require the operator to conduct an actual diversion during the validation flight.

The following emergency conditions should be demonstrated during the ETOPS validation flight unless successful demonstration of these conditions has been witnessed by the FAA in an acceptable simulation before the validation flight:

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

This simulator demonstration does not alter the operator’s requirement to demonstrate the competence and the capability to adequately support the intended operation during the ETOPS validation flight.

(b) Operational Approval

Following completion of the ETOPS application requirements and before the issuance of operations specifications, the operator's application with supporting data and the certificate-holding district office's principal inspectors' (Principal Maintenance Inspector, Principal Avionics Inspector and Principal Operations Inspector) recommendations should be forwarded to the Director, Flight Standards Service, for review and concurrence. Following review and concurrence by the Director, the validation flight, as required in Section 14(a), should be conducted in accordance with any additional guidance specified in the review and concurrence. Following the completion of a successful validation flight, operations specifications authorizing ETOPS operations will be issued to the certificate holder.

Operations specifications for ETOPS provide authorizations and limitations covering at least the following:

- Approved airframe/engine combination(s)
- Current approved CMP standard required for ETOPS, if appropriate
- Authorized geographic area(s) of operation
- ETOPS area of operation
- Airports authorized for use, including alternates and associated instrument approaches and operating minima
- Approved maintenance and reliability program for ETOPS including those items specified in the type design approved CMP standard, if appropriate
- Identification of the airplanes authorized for ETOPS by make, model and serial and registration number

15. CONTINUING SURVEILLANCE

The FAA monitors continuously the fleet average IFSD rate for ETOPS authorized airframe/engine combinations to ensure that the levels of reliability achieved in ETOPS remain at the required levels. If an acceptable level of reliability in fleet average IFSD is not maintained or if significant deficiencies or adverse trends are detected in type design or in the operation, the FAA may require the airframe and engine manufactures to develop a plan acceptable to the FAA to address the deficiencies. The certificate holding district office (CHDO) may initiate a special evaluation, which may result in the imposition of any prudent operational restriction necessary, and corrective action required of an operator in order to resolve problems in a timely manner. If any problem associated with airplane design is identified, the CHDO should notify the aircraft certification office (ACO) responsible for type design approval. As with all other operations, the certificate holding district office should monitor all aspects of the ETOPS it has authorized to assure that the operation continues to be conducted safely.

APPENDIX 1 ETOPS Approval (up to 180 minutes): IN-SERVICE EXPERIENCE method

An in-service experience program is one way of gaining ETOPS operational approval. As a prerequisite to obtaining any operational approval, it should be shown that an acceptable level of propulsion system reliability has been achieved in service by the world fleet for that particular airframe/engine combination. The candidate operator needs also to obtain sufficient maintenance and operation familiarity with the particular airframe/engine combination in question. Each operator requesting approval to conduct extended range operations by in-service method should have operational experience appropriate to the operation proposed.

This Appendix contains guidelines for requisite in-service experience. These guidelines may be reduced or increased following review and concurrence on a case-by-case basis by the Director, Flight Standards Service. Any reduction or increase in in-service experience guidelines will be based on an evaluation of the operator's ability and competence to achieve the necessary reliability for the particular airframe-engine combination in extended range operations. For example, a reduction in in-service experience may be considered for an operator who can show extensive in-service experience with a related engine on another airplane, which has achieved acceptable reliability. In contrast, an increase in in-service experience may be considered for those cases where heavy maintenance has yet to occur and/or abnormally low number of takeoffs has occurred.

75 and 90 Minute Operation Consideration may be given to the approval of 75 minute and 90 minute long range operations for operators with minimal or no in-service experience with the airframe/engine combination. This determination considers such factors as the proposed area of operations, the operator's demonstrated ability to successfully introduce airplanes into operations, and the quality of the proposed maintenance and operations programs.

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

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

Before approval, the operator's capability to conduct operations and implement effective ETOPS programs in accordance with the criteria detailed in this AC will be examined. Only operators who have demonstrated capability to conduct a 120-minute program successfully will be considered for approval beyond 120 minutes. Approval will be given on a case-by-case basis for an increase to their area of operation beyond 120 minutes. The dispatch limitation will be a maximum diversion time of 180 minutes to an ETOPS alternate at an approved one engine inoperative speed (under standard conditions in still air).

Requesting Approval An operator requesting approval under 14 CFR 121.161 for ETOPS under this Appendix should submit the requests, with the required supporting data, to the certificate-holding district office at least 60 days before the proposed start of ETOPS operation with the specific airframe/engine combination. In considering an application from an operator to conduct ETOPS, an assessment should be made of the operator's overall safety record, past performance, flight crew training, and maintenance programs. The data provided with the request should substantiate the operator's ability and competence to safely conduct and support these operations and should include the means used to satisfy the considerations outlined in this paragraph.

The following checklists are provided to facilitate the application for ETOPS approval under this In-service Experience method.

ETOPS APPLICATION CHECKLIST (In-service Experience Method) - MAINTENANCE

I. Type Design

A. Date of type design and review of each airframe/engine for ETOPS.

B. In-service experience for each airframe/engine combination:

1. Show number of months / years of operational experience with the specific airframe/engine combination.
2. Show the total number of ETOPS and / or domestic operations conducted with the specific airframe/engine.
3. Airframe/engine hours and cycles:
   - (a) Total
   - (b) High time engines
4. In-flight shutdown rate (all causes):
   - (a) Show 12 month and 6 month rolling average for ETOPS fleet.
   - (b) Show world fleet data (6 and 12 month rolling averages)
5. Unscheduled engine removal rate:
   - (a) World fleet
   - (b) Operator data
6. Mean time between failure (MTBF) major components
7. Record of APU start and run reliability
8. Show record of delays and cancellations.
   Identify causes by aircraft system.
9. Show record of significant operator events:
   - (a) Uncommanded power changes (surge or roll back)
   - (b) Inability to control engine or obtain desired power
   - (c) Total number of in-flight shutdown events.
   - (d) Diversions - ETOPS fleet
     Indicate phase of flight where event occurred and cause (mechanical, fuel or weather)

ETOPS Maintenance Requirements

Supplemental ETOPS Maintenance Program

I. ETOPS Manual

A. Should be identified as a chapter in the general maintenance manual

B. The manual should be submitted to FSDO 60 days before the implementation of ETOPS flights.

C. Preclude identical action being applied to multiple similar elements in ETOPS critical system. (e.g., fuel control change on both engines)

D. ETOPS tasks should be identified on routine work forms and instructions.

E. ETOPS procedures should be clearly defined in maintenance program, such as:
   Centralized maintenance control

F. ETOPS service check should be developed

1. Verify the airplane status and ensure that certain critical items are acceptable.
2. This check should be signed off by an ETOPS qualified person

II. **Oil Consumption Program**

Should reflect manufacturers' recommendations

1. Sensitive to oil consumption trends
2. Record the amount at dispatch stations
3. Monitor running average consumption.
4. SOAP samples, if meaningful to make and model
5. APU should be added to the program

III. **Engine Condition Monitoring**

Describe the parameters to be monitored.

1. Method of data collection
2. Corrective action process
3. Purpose to detect deterioration at an early stage

IV. Resolution of Airplane Discrepancies

A. Verification program to ensure corrective action following:

1. Engine shutdown
2. Primary system failure
3. Adverse trends or any events, which require verification flight (or other action to assure their accomplishment)

B. A clear description of who must initiate verification actions and the section responsible for the determination of what action is necessary

1. Primary systems (APU)
2. Conditions requiring verification actions should be described in the maintenance manual

V. Reliability Program

A. Event oriented

B. Incorporate reporting procedures (72 HRS) for significant events detrimental to ETOPS

1. In addition to the items in mechanical reliability reports (14 CFR 121 .703), the following are included:
   (a) In-flight shutdowns
   (b) Diversion or turnback
   (c) Uncommanded power changes or surges
   (d) Inability to control the engine or obtain desired power
   (e) Problems with systems critical to ETOPS
   (f) Any other event detrimental to ETOPS
2. The report should identify the following:
   (a) Airplane identification (make and "N" number)
   (b) Engine identification (make and serial number)
   (c) Total time, cycles and time since last shop visit
   (d) For systems: TSO or last inspection of the unit
   (e) Phase of flight
   (f) Corrective action

VI. Propulsion System Monitoring (IFSD)

A. Firm criteria should be established to take action

1. .05/1000 engine hours for 120 minutes
2. .03/1000 engine hours for 180 minutes

B. Immediate evaluation

VII. Maintenance Training

A. Focus on special nature of ETOPS and maintenance requirements

VIII. ETOPS Parts Control

A. Ensures proper parts and configuration are maintained for ETOPS

B. Verification that parts placed on ETOPS airplanes during parts borrowing or pooling arrangements

C. In addition to those parts used after repair or overhaul

ETOPS APPLICATION CHECKLIST (In-service Experience Method) - OPERATIONS

1. **Date of type design approval** of each airframe/engine for ETOPS. Maximum diversion time approved for the airframe/engine.

In-service experience for each airframe/engine combination:

Note: The data for item 2 may be submitted in the maintenance portion of the application.

a. **Number of months / years of operational experience** with the specific airframe/engine combination.

b. **Approximate total number of ETOPS and/or domestic operations** conducted with the specific airframe/engine combination.

c. **Airframe / engine hours and cycles**:

(1) Total

(2) High time engines

d. **In-flight shut down (IFSD) rate** (all causes):

(1) Operator data: Show 12-month and 6-month rolling average for the operators ETOPS fleet.

(2) World fleet data: Show 12-month and 6-month rolling average for specific ETOPS airframe / engine combination.

(3) Show 12-month and 6-month rolling average for other related airframe / engines used by the operator.

e. **Unscheduled Engine Removal Rate**:

(1) Operator

(2) World fleet

f. **Record of APU start and run reliability**. Show altitudes; where start attempts were made and where successful show outside temperature and peak EGT. Sample size should be agreed between operator, PMT, and AFS-330.

g. **Record of delays and cancellations**. Identify causes by aircraft system.

h. **Record of significant operator events** (domestic and international flights, if applicable):

(1) Uncommanded power changes (surge or roll back).

(2) Inability to control engine or obtain desired power.

(3) Total number of in-flight shutdown events.

(4) Diversions - show record of diversions by the operator s ETOPS fleet.

(a) Indicate phase of flight where event occurred.

(b) Indicate cause of event - mechanical, weather, fuel, etc.

(c) Indicate any significant problems encountered during the diversion.

i. **Problems in systems critical to the safety of ETOPS:** e.g., flight control, navigation, communication, electric, hydraulic, pneumatic.

3. Authorized area of operations for each airframe / engine combination.

a. **Show maximum diversion time and distance from an adequate airport**. Show performance chart, which is used to calculate the distance.

b. **Show terrain clearance along planned and diversion routes**:

(1) Show highest critical obstruction - elevation and location.

(2) Provide copy of NET selected high speed (e.g., LRC, 310 or 320) single engine inoperative altitude capability chart.

(3) Provide copy of Gross high speed single engine inoperative altitude capability chart.

(4) Calculate obstacle clearance as follows:
(i)The diversion profile/airspeed used to calculate the area of operations should be used in evaluating obstacle clearance;
(ii) NET performance data should be used;
(iii) Maximum possible diversion gross weight should be used;
(iv) Plus 10 temperature deviation should be used;
(v) Wing and engine anti-ice should be assumed to be OFF;
(vi) Advantage may be taken of drift down from cruise altitude to single engine inoperative cruise altitude; and
(vii) All terrain and obstructions should be cleared by 2000 feet.

NOTE: For the purposes of determining a critical obstruction in Greenland the operator may consider terrain and obstructions on or south of line drawn between Kulusuk (KK) NDB and the Sondrestrom (SF) NDB. If the operator chooses to select the critical obstacle from this area, then they should be prohibited in Ops Specs from operating across Greenland north of this line.
c. **Plotting Chart showing area of operations**. Diversion distance circles should be plotted from enroute alternates used to calculate the area of operations.
4. Dispatch limitation - Show dispatch limitation (e.g. 120 minutes/825 nautical miles).
NOTE: Not applicable to 75 min Caribbean/Western Atlantic area.
5. En route alternates:
a. **Sample ops spec page** showing airports to be used for ETOPS dispatch.
b. **Indicate compliance with** landing distances, services, and facilities.
c. **Show consideration of enroute alternate minimums and crosswind component** in selection of enroute alternates.
(1) **Show maximum crosswind component** used for ETOPS alternate selection at dispatch.
(2) Ensure enroute alternate minimums comply with Ops Specs paragraph C055.
d. **Show compliance with** evaluation of alternate conditions during the en-route phase.
e. Show training for airports, which are designated, as special airports in AC 121-445.
6. Copy of MEL showing compliance with MMEL. (For each airframe/engine combination, if necessary.)
NOTE: 75 min, Caribbean/Western Atlantic area does not require ER-MMEL items.
7. Sample copy of:
a. **Dispatch release**
b. **Computer flight plan**
c. **Plotting chart** with annotations required for typical flight (e.g., ETP's, route of flight). May be shown on plotting chart submitted under item 3c.
8. Communication and Navigation Facilities - indicate compliance with Section 13 of this AC
9. Airplane Performance Data: For each airframe/engine combination show operations manual pages used to comply with Section 11(a) of this AC
10. Fuel and Oil Supply compliance with Section 10(e)(5) of this AC
11. Flightcrew Training and Evaluation Program:
a. Show where **flight crew training items identified** in Section 11 of this AC are covered

b. Show policy for complying with Section 11(c) **ETOPS check airman program** of this AC.
c. **Show that any training issues, if appropriate,** identified in the Airplane Assessment Report have been incorporated in the training program.
12. Dispatch training Syllabus:
a. **Familiarity with AC 120-42**
b. **Selection of alternate**
c. **Alternate requirements** - landing distance, weather, facilities.
d. **MEL ER** items.
e. **Content of dispatch release**.
f. **En route procedures** - notify in case of change in alternate conditions.
g. **Section 11(e) fuel supply**
h. **Training for forecasting** (if req.).
i. **Area of operation and dispatch limitation**.
13. Compliance with 14 CFR 121.565:
a. **Equi-Time Points** (ETPs) and / or FMS use
b. **Immediate initiation of diversion**
c. **Authority of PIC**
14. Weather
(1) Staffing.
(2) Dispatcher training (if applicable).
(3) Sources of reports and forecasts.
(4) Record showing forecast reliability - forecast versus actual for a representative period of operation.
15. Equipment.
(1) VHF and/or satellite data link.
(2) Automated system monitoring
16.. Plan of Validation Flight or Flights:
a. Proposed dates.
b. Diversion required?
c. Revenue or non-revenue

APPENDIX 2 ETOPS Approval (up to 180 minutes): SIMULATION AND DEMONSTRATION Method

1. PURPOSE The purpose of this Appendix is to establish guidelines for a 14 CFR 121 operator, for whom 120 minute ETOPS is not practical, to conduct an acceptable ETOPS simulation and demonstration program leading to FAA approval to conduct 180 minute ETOPS.

2. FLIGHT SAFETY The operator should show that it has considered the impact of the ETOPS simulation / demonstration program on actual operations. The operator should state in its application its policy guidance to personnel involved in the ETOPS simulation / demonstration program regarding flight safety. This guidance should clearly state that simulated ETOPS programs exercises should not be allowed to impact the safety of actual operations, especially during periods of abnormal or emergency operations or high flight deck workload. It should emphasize that during these periods, ETOPS simulation should be terminated.

3. SIMULATION / DEMONSTRATION PROGRAM REQUIREMENTS The following is a list of the basic elements of an acceptable simulation / demonstration program. These elements should be addressed both in the operator's application and during operations conducted under this program. Specific guidance for these items as they relate to the simulation / demonstration program can be found in paragraph 4, Concepts for Simulation:

a. A fully developed and approved maintenance program which includes a tracking and control program

b. Approved airframe, system and engine reliability monitoring and reporting systems

c. An approved flight planning and dispatch program

d. An approved initial and recurrent training and checking program for specific flight operations personnel

e. An approved initial training and qualification program for ETOPS maintenance personnel

f. A simulation scenario of sufficient frequency and operational exposure to demonstrate the application and response of maintenance and operations support systems

g. A means to monitor and report ongoing ETOPS performance results during the period of the simulation to provide validation or, as necessary, recommended changes to ETOPS maintenance and operations support systems

h. A resource allocation and decision-making process which will demonstrate commitment by operator management and all operator personnel involved in ETOPS maintenance and operations support

4. CONCEPTS FOR SIMULATION To the extent possible, the simulation should provide an accumulation of in-service experience equivalent to actual ETOPS.

a. Simulated ETOPS Area of Operation and Dispatch Limitation The operator should identify a simulated ETOPS area of operation and the ETOPS alternates that it proposes within the simulated ETOPS area of operation.

b. Sample Size The operator should plan to conduct simulated ETOPS with the specified airframe-engine combination for at least 12-consecutive months. The sample size should consist of approximately 1000 separate operations. These operations should be conducted on flights, which contain approximately 3 hours of cruise flight. The number of operations and months of in-service experience may be increased or decreased following a review by AFS-1 considering:

(1) Operator experience with similar technology airframe-engine combinations in conducting ETOPS. e.g., 757 / 767 or A300 / A310
(2) Operator experience with the specified airframe-engine combination
(3) Operator experience with non-ETOPS airplanes in international overwater operations
(4) The record of the airplane-engine combination in ETOPS with other operations
(5) Other scenarios

c. Airframe-Engine Combination Build Standards

(1) Airframe It is recommended that airplanes proposed to be used in the simulated ETOPS program be configured to the CMP build standard for airframe items at the start of simulated ETOPS flights. Further, if certain equipment significantly impacts maintenance and / or operational procedures then the Director, Flight Standards Service may require that it be installed early in the simulation period. Airframe items, which the applicant intends to incorporate at a later date, should be identified in the application with a schedule for compliance. During the final three months of the simulation period, all airplanes used to conduct simulated ETOPS flights should comply fully with the CMP document.

(2) Engine / APU This statement applies equally to engine manufacturer items, engine build up systems and auxiliary power units on airplanes proposed to be used for simulated ETOPS flights. Normally the configuration, maintenance and operating items identified in the current FAA approved CMP document should be implemented before the start of simulated ETOPS flights. However, items identified in the CMP document by an asterisk may be accomplished per the manufacturer's recommended schedule.

(3) Delayed Configuration If there is a delay in configuring the operator’s airframe/engine combination (e.g., due to parts availability) the operator should continue the simulation phase until it is prepared to conduct the demonstration phase.

(4) Equipment for Extended Overwater Flight The applicant should identify any equipment required under 14 CFR 121 for extended overwater flight that is not installed at the start of simulated ETOPS. The applicant should provide the CHDO with a schedule for the installation of this equipment. If certain equipment significantly impacts maintenance and / or operational procedures, the Director, Flight Standards Service may require this equipment to be installed early in the simulation period.

d. Maintenance Programs The simulation program should be designed to aid the operator in developing ETOPS decision-making processes through the implementation of supplemental ETOPS maintenance programs under 14 CFR 121 and this AC. It is not within the scope of this Appendix to restate each required program element but rather to outline the extent of their application in a simulated maintenance program.

(1) Dispatch Considerations All dispatch actions, real or simulated, including documentation of discrepancies, should be completed before dispatch of the flight. An operator conducting an ETOPS simulation has available the same dispatch options that would be available for actual ETOPS.

(i) Minimum Equipment List (MEL) For instances in which the airplane does not meet the operator's ETOPS MEL requirements (but does meet non-ETOPS requirements), dispatch options should include:

(A) Taking appropriate action to comply with the ETOPS MEL and operate as an ETOPS flight

(B) Substitute an ETOPS airplane and operate as an ETOPS flight

(C) Operate the flight as a non-ETOPS flight

(ii) Domestic Verification Flights Instances in which the operator's program prescribes a domestic verification flight before ETOPS, dispatch options could include:

(A) Perform the verification flight in accordance with the approved FAA procedure and operate as an ETOPS flight

(B) Substitute an ETOPS airplane and operate as an ETOPS flight

(C) Operate the flight as a non-ETOPS flight

(2) ETOPS Destination Reliability Excessive use of the option to operate as a non-ETOPS flight is not desirable and indicates a lack of commitment to the ETOPS program. Therefore, during the period of simulation, ETOPS destination reliability should remain at 98% or higher. The following detail the guidelines for destination reliability requirements.

(i) An ETOPS flight is considered reliable if it arrives at its planned destination within 6 hours of its planned arrival time.

(ii) If an ETOPS flight does not arrive at its intended destination within 6 hours of planned arrival due to factors unrelated to the operator’s maintenance or operations programs, the flight may be counted as reliable. Flights delayed for reasons beyond the control of the operator, such as a passenger medical emergency, air traffic flow control or a flight rescheduled for passenger load considerations, should not be considered unreliable.

(iii) Flights conducted under the non-ETOPS MEL are not considered reliable for the destination reliability calculation.

(iv) Any ETOPS designated flight which is unreliable under the guidelines above should be reported to the principal maintenance inspector (PMI) with a copy to AFS-200 within 72 hours of the event. The report should include:

(A) If maintenance related, a description of the discrepancy or malfunction that caused the flight to be unreliable, including operating under a non-ETOPS MEL

(B) If operations related, a description of the operational problem that caused the flight to be unreliable

(C) Chronology of the problem from the time of first notification to maintenance or operations personnel until the time of flight termination or cancellation

(D) Actions which followed initial notification of the problem

(E) Logistical aspects surrounding the availability of repair parts and / or required maintenance equipment at the station where the problem occurred

(F) Any other information that may be deemed pertinent to the factors, which caused the flight to be unreliable

(v) The operator should compile destination reliability data and report to the PMI with a copy to AFS-200 each month starting from the beginning of ETOPS simulation. This report should include:

(A) Number of flights scheduled during the period and the total number scheduled since start of ETOPS simulation
(B) Number of flights considered reliable and unreliable during the period and since start of ETOPS simulation
(C) Percentage of flights considered reliable during the period and since the start of ETOPS simulation
(D) In-service experience data to include inflight shut down (IFSD) rates, (3-month, 6-month and 12-month rolling averages, as agreed with the PMI), unscheduled engine removals and rates, delays and cancellations, airframe-engine hours and cycles, record of APU start and run reliability and any other significant operator events required to be reported under 14 CFR 121 and this AC. Data, such as IFSD rates and events, for portions of the applicant's airplane-engine combination fleet which are not intended to be utilized in the ETOPS simulation also should be reported.

e. Operations Programs

(1) Training Pilots and dispatchers who participate in the simulation should have received ETOPS and international flight operations training before participating in the ETOPS simulation.

(2) Operations Flights should be planned, dispatched and flown in accordance with this Appendix. All dispatch actions, real or simulated, including documentation of discrepancies, should be completed before dispatch of the flight. (See paragraph 4.d.(2), ETOPS Destination Reliability Requirements). During ETOPS simulated flights, pilots and dispatchers should evaluate:
(i) ETOPS alternate and reserve fuel
(ii) ETOPS alternates suitability
(iii) Computer flight plans, including diversion data such as equi-time points (ETPs), ETOPS alternate fuel requirements, heading / track information
(iv) Minimum Equipment List (MEL) items
(v) Plotting charts - Navigation plotting charts should be annotated during flight planning, as they would be for an actual flight. En route plots should be made as recommended in AC 90-79.
(vi) HF communications - HF communications should be used to familiarize pilots with the unique operational characteristics of HF.
(vii) Technical assistance - Exercises should be conducted on selected flights to evaluate the availability and quality of assistance from maintenance technical centers.

5. PAPER AIRLINE EVALUATION To validate the accuracy and repeatability of data sources, flight planning methodology and algorithms, and operational decision processes, a "paper airline" data collection and analysis should be conducted in parallel with both the simulation and demonstration phases.

a. Area of Operation The "paper airline" shall be "flown" over the exact route(s) intended for the planned, scheduled ETOPS flights.

b. Sample Size and Timing A minimum of one flight per business day per intended route segment should be planned. "Business day" is that period during which normal duties permit data retrieval and analysis. Where the frequency is less than daily, the "paper" scenario should maintain a minimum analysis volume of 5 flights per week.

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

d. Configuration Compliance Although not applicable, it should be assumed that the "paper" airplane in the planning database for the daily analyses is fully conformed to CMP and ETOPS MEL requirements.

e. Paper Flight Analysis For each paper flight, planned versus actual weather and facility status should be analyzed. Items to be analyzed should include:

(1) Actual versus forecast weather and field conditions for ETOPS alternates, destination and terminal alternate, including ceiling, visibility, crosswind component and runway conditions

(2) Actual versus forecast en route weather, including icing

(3) Actual versus anticipated condition of navigation, communications and airport facilities to support en route and terminal operations, including potential operations to ETOPS and terminal alternates

(4) Analysis of planned versus actual en route winds designed to evaluate the accuracy of en route fuel burn and planned ETOPS alternate and reserve fuel

f. Presentation of Results During the domestic simulation phase, results from the ongoing daily "paper airline" analyses should be made available for FAA review and comment. Summary reports should be prepared and forwarded monthly to the CHDO with a copy to AFS-200, including revised program elements or strategies innovated as a result of conclusions derived from the parallel analyses.

APPENDIX 3 ETOPS Approval (up to 180 minutes): ACCELERATED ETOPS Method

This Appendix describes the means by which an operator may initiate ETOPS operations when the operator establishes the processes necessary for successful and reliable ETOPS operations and proves to the Administrator that such processes can be successfully applied throughout the applicant's ETOPS operations. This may be achieved by thorough documentation of processes, demonstration on another airplane/validation (as described under Process Validation in this Appendix, below) or a combination of these processes.

No checklist similar to the Maintenance and Operations checklists provided in Appendix 1 (In-service Experience) is provided, as the format of this appendix (Appendix 3) itself can serve as a checklist.

ETOPS Processes

The two-engine airframe-engine combination for which the operator is seeking accelerated ETOPS Operational Approval must be ETOPS Type Design approved and determined to be operating at a satisfactory level of reliability before commencing ETOPS. The operator seeking accelerated ETOPS Operational Approval must demonstrate to the FAA that it has an ETOPS program in place that addresses the process elements identified in this Appendix.

The following are the ETOPS process elements:

- Airplane/engine compliance to CMP.
- Compliance with the maintenance requirements defined in Section 10 of this AC:
  - Fully developed Maintenance Program which includes a tracking and control program.
  - ETOPS manual. (In place.)
  - A proven Oil Consumption Monitoring Program.
  - A proven Engine Condition Monitoring and Reporting system.
  - A proven Plan for Resolution of Airplane Discrepancies.
  - A proven ETOPS Reliability Program.
  - Propulsion system monitoring program in place. The operator should establish a program that results in a high degree of confidence that the propulsion system reliability appropriate to the ETOPS diversion time would be maintained.
  - Training and qualifications program in place for ETOPS maintenance personnel.
  - Established ETOPS parts control program.
- Compliance with the flight operations program defined in Section 11 of this AC:
  - Proven flight planning and dispatch programs appropriate to ETOPS.
  - Availability of meteorological information and MEL appropriate to ETOPS.
  - Initial and recurrent training and checking program in place for ETOPS flight operations personnel.
  - Flight crew and dispatch personnel familiarity assured with the ETOPS routes to be flown; in particular the requirements for, and selection of, ETOPS alternates.
- Documentation of the following elements:

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

Application
Normally, requests for extended range operations are to be submitted at least sixty (60) days before the start of extended range operations. However, the operator seeking accelerated ETOPS operational approval should submit an ETOPS Operational Approval Plan to the FAA six (6) months before the proposed start of ETOPS. This time will permit the FAA to review the documented plans and assure adequate ETOPS processes are in place. The operator's application for ETOPS should:

- Define proposed routes and the ETOPS diversion time necessary to support these routes.
- Define processes and related resources being allocated to initiate and sustain ETOPS operations in a manner that demonstrates commitment by management and all personnel involved in ETOPS maintenance and operational support.
- Where required, identify the plan for establishing compliance with the build standard required for Type Design Approval, i.e. CMP compliance.
- Document plan for compliance with requirements above.
- Define Review Gates. A review gate is a milestone tracking plan to allow for the orderly tracking and documentation of specific requirements of this Appendix. Each review gate should be defined in terms of the tasks to be satisfactorily accomplished in order to be successfully passed. Items for which the FAA visibility is required or the FAA approval is sought should be included in the Review Gates. Normally, the Review Gate process will start six (6) months before the proposed start of extended range operations and should continue at least until six (6) months after the start of extended range operations. Assure that the proven processes comply with the provisions of this AC.

Operational Approvals

Operational approvals will be limited to those areas agreed to by the FAA with the approval of the accelerated ETOPS Operational Approval Plan. If an operator wishes to add new areas to the approved list, FAA concurrence is required.
Under this method, operators will be eligible for ETOPS Operational Approval up to the type design approval limit or 180 minutes, whichever is less, provided the operator complies with all the requirements under the title, ETOPS Processes, in this Appendix, above.

Process Validation

The section, ETOPS Processes, above identifies those process elements that should be proven before the start of ETOPS under the accelerated ETOPS approval program.
For a process to be considered proven, the process must first be defined. Typically, this will include a flow chart showing the various elements of the process. Roles and responsibilities of the personnel who will be managing this process should be defined including any training requirement. The operator should demonstrate that the process is in place and functions as intended. The operator may accomplish this by thorough documentation and analysis, or by demonstrating on an airplane, that the process works and consistently provides the intended results. The operator should also show that a feedback loop exists to illustrate need for revision of the process, if required, based on in-service experience.

Normally the choice to use or not to use demonstration on an airplane as a means of validating the process should be determined by the operator. With sufficient preparation and dedication of resources, such validation may not be necessary to assure processes that produce acceptable results. However, if the plan proposed by the operator to prove processes is determined by the FAA to be inadequate or the plan does not produce acceptable results, validation of the process with an airplane will be required.

If an operator currently is conducting ETOPS with a different airframe/engine combination, it may be able to document that it has proven ETOPS processes in place with only minimal further validation required. The operator should demonstrate that the means are in place to assure equivalent results with the airplane/ engine combination being proposed for ETOPS operational approval. The following elements may aid in justifying a reduction in the requirement validation of ETOPS processes:

- Experience with other airframes and/or engines
- Previous ETOPS experience
- Experience with long range, overwater operations with two-, three-, or four-engine airplanes
- Experience gained by flight crews, maintenance personnel and flight dispatch personnel while working with other ETOPS-approved operators

Process validation may be done with the airframe/engine combination that will be used in ETOPS or with a different airplane type from that for which ETOPS approval is being sought, including an airplane with more than two engines. A process may be validated by first demonstrating the process produces acceptable results on a different airplane type or airframe/engine combination. It then should be necessary to demonstrate that means are in place to assure equivalent results should occur on the airplane being proposed for accelerated ETOPS Operational Approval. However, final approval for accelerated ETOPS authority will be granted only after an operational validation flight, as required in Section 14(a) accomplished in the airframe-engine combination (AEC) of the operator's application.

Any validation program should address the following:

- The operator should show that it has considered the impact of the ETOPS validation program with regard to safety of flight operations. The operator should state in its application any policy guidance to personnel involved in the ETOPS process validation program. Such guidance should clearly state that ETOPS process validation exercises should not be allowed to adversely impact the safety of operations especially during periods of abnormal, emergency, or high cockpit workload operations. It should emphasize that during periods of abnormal or emergency operation or high cockpit workload ETOPS process validation exercises may be terminated.
- The validation scenario should be of sufficient frequency and operational exposure to validate maintenance and operational support systems not validated by other means.
- A means must be established to monitor and report performance with respect to accomplishment of tasks associated with ETOPS process elements. Any recommended changes to ETOPS maintenance and operational process elements should be defined.
- Before the start of the process validation program, the following information should be submitted to the FAA:
  - Validation periods, including start dates and proposed completion dates.
  - Definition of airplane to be used in the validation. List should include registration numbers, manufacturer and serial number and model of the airframes and engines.
  - Description of the areas of operation (if relevant to validation objectives) proposed for validation and actual extended range operations.
  - Definition of designated ETOPS validation routes. The routes should be of duration necessary to ensure process validation occurs.
- Process validation reporting. The operator should compile results of ETOPS process validation. The operator should:
  - Document how each element of the ETOPS process was utilized during the validation.
  - Document any shortcomings with the process elements and measures in place to correct such shortcomings.
  - Document any changes to ETOPS processes that were required after an inflight shutdown (IFSD), unscheduled engine removals or any other significant operational events.
  - Provide periodic process validation reports to the FAA. This may be addressed during the review gates.

APPENDIX 4 ETOPS Approval: 138 MINUTE ETOPS (120 Minute ETOPS Extension)

Operators with existing 120 minute or greater ETOPS authority may apply for 138 minute ETOPS authority by letter application to AFS-200 through the CHDO. The ETOPS authority will be granted by the Director, Flight Standards Service, AFS-1 and will be reflected in the operator's operations specifications. The application should include the following information as a minimum:

- Present ETOPS diversion authority (e.g.., 120 / 180 minutes)
- The airframe/engine combination(s) presently authorized ETOPS and the airframe/engine combinations for which 138 minute ETOPS approval is being sought
- The 12-month rolling inflight engine shutdown (IFSD) rate(s) for the airframe-engine combination(s) included in the 138-minute ETOPS application. A world fleet average of minimum IFSD rate of .05/1000 engine hours will be required for 138 minute ETOPS with the objective to continue improvement toward an IFSD rate of .02/1000 engine hours
- The area of operation requested for 138 minute ETOPS diversion authority

APPENDIX 5 ETOPS Approval Beyond 180 minutes- Two-Engine Airplanes

Operators applying for authority under this appendix must be currently approved for 180 minutes ETOPS authority and have a demonstrated ETOPS service record. Operators with existing 180 minute ETOPS authority on the airframe/engine combination may apply for ETOPS authority beyond 180 minutes by letter application to AFS-200 through the CHDO. The applicant will be required to conduct an operational validation flight in accordance with Section 14(a) of this AC to demonstrate the intended operation. The ETOPS beyond 180 minutes authority will be granted by the Director, Flight Standards Service, AFS-1, and will be reflected in the operator's operations specifications. The application should include the following as a minimum:

- Current ETOPS authority (e.g., 180 minutes)
- Airframe/engine combination for which ETOPS beyond 180 minutes approval is being sought
- Area of operation requested for ETOPS beyond 180 minutes authority
- A summary of revisions made to operational documents
- A summary of the revision to training curricula for maintenance, dispatch and flight crew personnel which distinguishes ETOPS training material beyond 180 minutes from 180 minute ETOPS training material

APPENDIX 6 ETOPS Approval Beyond 240 minutes- Two-Engine Airplanes

Approvals may be granted, to operators who have been operating in accordance with 180 min or greater ETOPS for 24 consecutive months of which at least 12 consecutive months shall be at 240 minutes ETOPS on the airframe/engine combination for which the authority is requested, to conduct ETOPS with maximum diversion times beyond 240 minutes. The approval process shall be based on a review of the applicant's experience in 240 minute ETOPS and the applicant's unique operation and operating environment for issues that would impact ETOPS beyond 240 minutes.

Operators with existing 240 minute ETOPS authority may apply for ETOPS authority beyond 240 minutes by letter application to AFS-200 through the CHDO. The applicant will be required to conduct an operational validation flight in accordance with Section 14(a) of this AC to demonstrate the intended operation. The ETOPS beyond 240 minutes authority will be granted by the Director, Flight Standards Service, AFS-1, and will be reflected in the operator's operations specifications. The application should include the following as a minimum:

- Current ETOPS authority (e.g., 240 minutes)
- Airframe/engine combinations presently authorized for ETOPS and the airframe/engine combination(s) for which ETOPS beyond 240 minutes approval is being sought
- City pairs in the area of operation requested for ETOPS beyond 240 minutes authority. For each city pair, a new validation flight in accordance with Section 14(a) of this AC may be required.
- A summary of revisions made to operational documents
- A summary of the revision to training curricula for maintenance, dispatch and flight crew personnel which distinguishes ETOPS training material beyond 240 minutes from 240 minute ETOPS training material

APPENDIX 7 ETOPS Beyond 180 Minutes Approval - Airplanes with More Than Two Engines

An operator may apply for ETOPS beyond 180 minutes authority by letter application to AFS-200 through the CHDO. The applicant will be required to conduct an operational validation flight in accordance with Section 14(a) of this AC to demonstrate the intended operation. The ETOPS beyond 180 minutes authority will be granted by the Director, Flight Standards Service, AFS-1, and will be reflected in the certificate holder's operations specifications.

The application should include the following as a minimum:

- Compliance with the maintenance and flight operations guidance in Sections 10 and 11 of this AC.
- Airframe/engine combinations for which ETOPS beyond 180 minutes approval is being sought
- Area of operation requested for ETOPS beyond 180 minutes authority. If applying for polar ETOPS approval, compliance with guidance in Section 12.
- A summary of revisions made to operational documents
- A summary of the revision to training curricula for maintenance, dispatch and flight crew personnel which distinguishes ETOPS training material

Advisory Circular 135-44
Polar Operations

PURPOSE. This Advisory Circular (AC) provides an acceptable means, but not the only means, of conducting Polar Operations in accordance with 14 CFR 135.98.

A. CANCELLATION. None

B. PRINCIPAL CHANGES. This is a new Advisory Circular.

C. RELATED READING MATERIAL

1. AC 120-52, Radiation Exposure Of Air Carrier Crewmembers,

2. AC 120-61, Crewmember Training On In-Flight Radiation Exposure

D. Airport Requirements For Designation as Polar-Diversion Airports. Prior to each flight, certificate holders should designate one or more airports that can be reasonably expected to be available in case an enroute diversion is necessary. The airplane must be able to make a safe landing and the airplane maneuvered off the runway at the diversion airport. In addition, those airports identified for use during an enroute diversion should be capable of protecting the safety of all personnel by allowing:

1. Safe offload of passengers and crew during possible adverse weather conditions;
2. Providing for the physiological needs of the passengers and crew until a safe evacuation is completed, and;
3. Safe extraction of passengers and crew as soon as possible (execution and completion of the recovery should be within 12 to 48 hours following landing).

E. Recovery Plan For Passengers At Diversion Alternates. All certificate holders conducting polar operations should have a plan for recovering passengers at designated diversion airports. The recovery plan should address the care and safety of passengers and crew at the diversion airport.

F. Fuel Freeze Strategy And Monitoring Requirements For Polar Operations. A certificate holder may develop a fuel freeze analysis program in lieu of using the standard minimum fuel freeze temperatures for specific types of fuel used. In such cases, the operator's fuel freeze analysis and monitoring program for the airplane fuel load must be submitted and acceptable to the FAA. The operator should have procedures established that requires coordination between maintenance and flightcrew of the determined fuel freeze temperature of the actual fuel load on board the airplane.

G. **MEL Considerations For Polar Operations.** Prior to receiving approval to conduct polar operations, a certificate holder must amend its MEL for the following systems/equipment to indicate that they are required for polar operations:

1. Fuel Quantity Indicating System (to include a fuel tank temperature indicating system),
2. Communication system(s) needed for effective communications by the flightcrew while in flight.
3. Expanded medical kit (AED).

H. **Training Issues For Polar Operations**. Prior to conducting Polar Operations, certificate holders must ensure flight crews are trained on the following items, which must also be included in a certificate holder's approved training programs:

1. QFE/QNH and meter/feet issues (flight crew training).
2. Training requirements for fuel freeze (maintenance and flight crew training).
3. General polar-specific training on weather patterns and aircraft system limitations (flight crew training).
4. Proper use of the cold weather anti-exposure suit, if required (flight crew training).
5. Radiation exposure (see AC 120-61, Crewmember Training On In-Flight Radiation Exposure)

I. **Special Equipment For Polar Operations.** Certificate holders should consider carrying a cold weather anti-exposure suit(s) on the airplane if outside coordination by a flight crew at a diversion airport with extreme climatic conditions will be necessary.

Advisory Circular 135-42
Extended Operations (ETOPS)

PURPOSE. This Advisory Circular (AC) provides an acceptable means, but not the only means, of conducting Extended Operations (ETOPS) in accordance with 14 CFR 135.364.

The intent of ETOPS is two-fold. First, to ensure that the factors that may cause an airplane to make an unanticipated en route diversion to another airport are minimized. Second, should the airplane be required to make such a diversion, the airplane is able to land safely, even when the airplane is operating over a geographic area where adequate airports are unusually distant.

Operations with multi-engine turbine-engine powered airplanes may be authorized over a route that contains a point farther than 180 minutes flying time, but 240 minutes or less flying time, from an airport meeting the requirements of §135.385 or §135.393 and §135.219 at an approved one-engine-inoperative cruise speed under standard conditions in still air.

This AC also provides useful information and guidance that could be useful for certificate holders conducting flights less than 180-minutes from an airport for other long range operations.

A. **CANCELLATION. None**

B. **PRINCIPAL CHANGES. This is a new Advisory Circular.**

C. **RELATED READING MATERIAL**

   a. **Title 14 Code of Federal Regulations**
      i. 14 CFR Part 135, Appendix G
      ii. 14 CFR Part 25, Appendix L

   b. **FAA Order 8100.X**

   c. **FAA Advisory Circulars**
      <u>AC 25-XX, "Type Design Approval for ETOPS"</u>
      <u>AC 33.100, "Turbine Engines Eligibility for Early ETOPS"</u>
      <u>AC 120.XX, "Extended Operations (ETOPS)"</u>

D. **Definitions**. The following definitions are applicable to ETOPS conducted in accordance with 14 CFR Part 135.

   a. **ETOPS:** Extended Operations. ETOPS is an operation authorized under 14 CFR Part 135 pertinent to flights beyond 180 minutes flying time (in still air at normal cruise speed with one engine inoperative) from an airport meeting the requirements of §135.385, §135.387, §135.393 or 135.395, as applicable, and §135.219 or 135.221 as applicable. However, ETOPS flights must be planned so as to remain within 240 minutes flying time (in still air with one engine inoperative) from an airport meeting the requirements of §135.385, §135.387, §135.393 or 135.395, as applicable, and §135.219 or 135.221 as applicable

b. **ETOPS Area of Operation:** The area between 180 minutes and 240 minutes flying time (as determined in the ETOPS definition above) from an airport meeting the requirements of §135.385 or §135.393, and §135.219 and §135.387.

c. **ETOPS Enroute Alternate Airport**: An airport designated by the certificate holder that that meets the following requirements:

   i. FAR §135.385, §135.387, §135.393 or 135.395, as applicable, and §135.219 or 135.221 as applicable. ; and,

   ii. Weather reports or forecasts or any combination thereof indicate that weather conditions are at or above operating minima specified in the certificate holder's operations specifications; and,

   iii. Field condition reports indicate that a safe landing can be accomplished at the time of the intended operation based on expected times of arrival.

(Note: This designation is a planning requirement. It does not in any way limit the decisions of the pilot in command during flight.)

d. **ETOPS Entry Point:** ETOPS entry point is the first point on the route of an authorized flight which is more than 180 minutes from a ETOPS enroute alternate airport. The ETOPS entry point is calculated at an approved one-engine inoperative cruise speed under standard conditions in still air.

e. **ETOPS Dual Maintenance:** Maintenance actions performed on the same element of identical, but separate ETOPS maintenance significant systems, during the same routine or non-routine visit. This is to recognize and preclude common cause human failure modes without proper verification process or operation test prior to ETOPS.

   i. For turbine engine powered airplanes with two engines - A maintenance action performed on the same element of identical but separate ETOPS maintenance significant systems during the same routine or non-routine visit.

   ii. For turbine engine powered airplanes with more than two engines - A maintenance action performed on the same element of identical but separate ETOPS maintenance significant systems on 2 engines of a 3 engine aircraft, or more than 1 engine per side of a 4 engine aircraft during the same routine or non-routine visit.

f. **ETOPS Maintenance Significant System**:

i. A system for which the redundancy characteristics are directly linked to the number of engines.

ii. A system that may affect the proper functioning of the engines to the extent that it could result in an in-flight shutdown or uncommanded loss of thrust.

iii. A system, which contributes significantly to the safety of a diversion.

g. **ETOPS Qualified Personnel** Personnel who have completed the appropriate ETOPS training program described in the FAA-approved Operations Manual or Maintenance Manual of an certificate holder approved to conduct ETOPS.

h. **Equal-Time Point (ETP)** A point on the route of flight where the flight time, considering wind, to each of two selected airports is equal.

i. **In-flight Shutdown (IFSD)** When an engine ceases to function in flight and is shutdown, whether self-induced, crew initiated or caused by some other external influence (i.e., IFSD for all causes; for example: due to flameout, internal failure, crew-initiated shutoff, foreign object ingestion, icing, inability to obtain and/or control desired thrust, etc.).

j. **One Engine Inoperative Cruise Speed (Approved)** For the purposes of the sections of 14 CFR Part 135 applicable to ETOPS, the one engine inoperative cruise speed is a speed selected by the certificate holder from a range of speeds approved by the FAA that is within the certificated operating limits of the airplane . This speed is used during a particular flight planning for calculating both fuel reserve requirements and the still air distance associated with the ETOPS area of operation for a specific flight.

k. **SATCOM** Satellite communication equipment.

E. BACKGROUND:

a. **ICAO Requirements**. The International Civil Aviation Organization's (ICAO) Standards and Recommended Practices, Annex 6, Part I; International Commercial Air Transport – Aeroplanes, states that unless the operation has been specifically approved by the State of the Certificate holder, no twin-engine aeroplane shall be operated on a route where the flight time at single engine cruise speed to an adequate airport exceeds a threshold time established for such operations. The United States is a signatory to ICAO.

b. **History of FAR Part 135 Long-Range Operations**. FAA and industry analysis of the accidents and incidents involving longer range operations conducted in accordance with 14 CFR Part 135 indicate that they have been conducted for many years with a high degree of safety without regulatory limitations on range. Prior to (*insert effective date of Part 135 rule*), no additional regulations had been promulgated. However, since 1998 it has been FAA's policy to limit flights conducted under FAR Part 135 to 180 minutes from an airport. In recent years, several manufacturers have produced new turbine-engine powered airplane with range capabilities that could take them well beyond 180 minutes from an airport. Because of their smaller maximum payload and seating capacity, despite their range capabilities, these airplanes are authorized to operate in accordance with 14 CFR Part 135.

Those geographic areas not within a 180-minutes of an airport tend to be remote areas of the world that are uniquely challenging for all certificate holders and airplanes, regardless of the number of engines, including such issues as extremes in terrain and meteorology and limited navigation and communications infrastructure. The margin of safety is increased when adequate consideration is made for a possible diversion and subsequent recovery in such areas. These considerations include additional crew and maintenance technician training, assurance that certain airplane equipment and systems are installed and functioning prior to takeoff, more thorough flight planning, and additional fuel reserves.

ETOPS requirements are intended to address all these issues, while also bringing FAA regulations into compliance with ICAO Standards and Recommended Practices.

F. CONCEPTS

a. **Risk Management and the Level of Safety.** Current service experience for the newest generation of engines developed for airplanes typically operated over long distances in accordance with 14 CFR Part 135 indicate that engine reliability is not the most significant issue for the safety of ETOPS or any long-range flight. As propulsion systems have achieved ever-increasing levels of reliability, other systems and operational issues have increased in their relevance to the overall level of safety of the flight.

The number of airplanes and operations conducted under ETOPS will remain relatively small for the foreseeable future. This greatly reduces the usefulness and reliability of safety trend analysis based on fleet averages of specific airframe/engine combinations. Accordingly, the means of ensuring an adequate level of safety for ETOPS is to require that certificate holders and manufacturers of airplane conducting ETOPS evaluate each reported malfunction, incident or accident pertaining to an airframe, power system or other critical component on an airplane that is relevant to the conduct of ETOPS. Subsequent to this evaluation, corrective action may be required on the part of the certificate holder or manufacturer before ETOPS operations continue.

b. **ETOPS Enroute Alternate Airport**. One of the distinguishing features of ETOPS operations is the concept of an enroute alternate airport being available where an airplane can divert after a single failure or combination of failures. Whereas most airplanes operate in an environment where there is a choice of diversion airports available within close proximity to the route of flight, an airplane conducting ETOPS may have only one alternate within a range dictated by the endurance of a particular airframe system. Therefore, it is important that any airport designated as a ETOPS enroute alternate airport has the capabilities and facilities to safely support the airplane and its passengers and crew for the diversion. The weather conditions at the time of arrival should provide high assurance that adequate visual references are available upon arrival at decision height (DH) or minimum descent altitude (MDA), and the surface wind conditions and corresponding runway surface conditions must be within acceptable limits to permit the approach and landing to be safely completed with an engine and/or systems inoperative.

When the airplane departs on a route planned for ETOPS, an enroute alternate must meet alternate weather requirements specified in the certificate holder's operations specifications. Due to the natural variability of weather conditions with time, as well as the need to determine the suitability of a particular enroute alternate prior to departure, such requirements are higher than the weather minimums required to initiate an instrument approach. This is necessary to assure that the instrument approach can be conducted safely if the flight must divert to an alternate airport. Additionally, as the visual reference necessary to safely complete an approach and landing is determined, among other things, by the accuracy with which the airplane can be controlled along the approach path by reference to instruments and the accuracy of the ground-based instrument aids, as well as the tasks the pilot is required to accomplish to maneuver the airplane so as to complete the landing, the weather minima for non-precision approaches are generally higher than for precision approaches.

While enroute, the forecast weather for designated ETOPS enroute alternate airports must remain at or above operating minima. This allows the pilot in command of a ETOPS flight to successfully resolve diversion decisions. While inflight, the suitability of a ETOPS enroute alternate airport is solely based on a determination that the weather and field conditions at that airport at the predicted time of arrival will permit an instrument approach to be initiated and a safe landing completed.

c. **Certificate Holder Experience.** Safety is enhanced when, prior to conducting ETOPS, a certificate holder gains operational experience in the type of airplane capable of ETOPS, and with the operational environment typically encountered on longer range flights (up to 180 minutes) in areas where airports available for an enroute diversion are limited. Typically, this involves prior operational experience on overwater flights to international areas of operation in accordance with 14 CFR Part 135. However, it is recognized that once a certificate holder is authorized to conduct ETOPS with one type of airplane, the procedures and systems are in place to support additional airplanes. Therefore, when a certificate holder currently authorized to conduct ETOPS adds additional ETOPS capable airplane types, the experience requirements of 14 CFR 135, Appendix G, Paragraph A, will not apply.

A firm commitment by the certificate holder to establish adequate ETOPS procedures before the start of actual operations, and continued commitment throughout the life of the program to continually review these procedures, is a significant factor in safe and reliable ETOPS.

d. **Preclude and Protect**. ETOPS is intended to preclude a diversion and, if it were to occur, have programs in place that protect that diversion. Under this concept, propulsion systems and other airplane systems are designed and tested to ensure an acceptable level of reliability. Maintenance practices monitor the condition of engines so as to identify problems before they cause diversions, and take aggressive steps to identify and resolve airplane systems and engine problems once they are identified. All are intended to minimize the potential for procedural and human errors, thereby precluding a diversion.

However, despite the best design/testing and maintenance practices for airplanes, situations may occur which require an airplane to divert. Regardless of whether the diversion is for technical (airplane or engine systems) or non-technical reasons (crew or passenger illness), there must be a flight operations plan to protect that diversion, ensuring it is successful. Such a plan may include ensuring that pilots are knowledgeable about the availability of enroute alternate airport alternates, weather conditions at those alternates, adequate ability to communicate with appropriate flight following services and air traffic control, sufficient fuel to divert to the alternate, etc.

Under the 'preclude and protect' concept, various failure scenarios must to be considered. For example, during the design of the airplane, time limited systems such as oxygen capability must be considered. Fuel planning accounts for the possibility of decompression or the failure of an engine with considerations for icing. The best options under any of these scenarios should be provided to the pilot before and during the flight.

Airplanes divert from time to time for various reasons, most of which are not related to failure of a powerplant. Airplanes with more than two engines also operate in areas where there are a limited number of enroute airports, the support infrastructure is marginal or there is challenging weather conditions. All ETOPS flights, therefore, regardless of the number of engines on the airplane, must adopt the same ‘preclude and protect’ concept. If airplanes with more than two engines plan to operate in areas where en route airports are farther than 180 minutes flight time, these operations are also required to meet the standards defined under ETOPS. This ensures that sufficient efforts are made to preclude a diversion and, if a diversion does occur, procedures are in place to protect that diversion.

e. **Operational Reliability/Systems Suitability**. The safety of long-range operations (ETOPS) depends on the reliability of all critical airplane systems, including the propulsion systems. Therefore, a comprehensive program to monitor the reliability of flight-critical systems is essential.

The conduct of long-range operations should consider the probability of any condition that reduces the capability of the airplane or the ability of the flight crew to cope with the adverse operating condition. System failures or malfunctions occurring during ETOPS could affect flight crew workload and procedures, so an assessment should be made to ensure that exceptional piloting skills or crew coordination are not required. Best options under the most likely scenarios must be provided to the pilot before and during the flight.

f. **ETOPS:** 14 CFR Part 135.364 permits operation of airplanes over a route that contains a point farther than 180 minutes flying time from an airport in still air at normal cruising speed with one engine inoperative when approved by the Administrator. Certificate holders must incorporate ETOPS requirements into their approved maintenance and operations programs. ETOPS must be authorized in the certificate holder’s operations specifications and conducted in compliance with those sections of Part 135 applicable to ETOPS, including Appendix G.

When planning a flight, certificate holders should determine if the flight can be reasonably planned to remain within 180 minutes of an airport. If the routing and expected conditions prevent the planned flight from remaining within 180 minutes of an airport, then operations specifications containing ETOPS authority for the airplane and applicable areas of operation will be required.

Airplanes used in ETOPS must be type-design approved for ETOPS or, if the airplane was first type-certificated before *(insert date that is eight years after the effective date of Part 25 Appendix L),* the airplane should be acceptable to the FAA Administrator. Section 9a. of this AC provides one description, but not the only description, of the types of airplane equipment and systems the FAA finds acceptable for an airplane certificated before *(insert date that is* *eight years after the effective date of Part 25 Appendix L)* to operate in accordance with ETOPS.

Two independent transmitters and two independent receivers, appropriate to the planned route, are required for ETOPS flights. At least one of each must be capable of voice communication. If operating in areas where voice communication is not possible or of poor quality, alternate systems (data link, satcom, etc.) may be used.

G. ETOPS Authorizations:

a. **Airplane**.

- **i.** FAR Part 135, Appendix G, paragraph (C) states that no person may operate a multi-engine airplane that was added to the certificate holder's U.S. operations specifications after [*insert date that is eight years after Part 25 Appendix L is adopted*] in accordance with ETOPS unless the airplane is certificated to FAR Part 25, Appendix N.
- **ii.** Multi-engine airplanes added to an certificate holder's U.S. operations specifications on or before [*insert date that is eight years after Part 25 Appendix L is adopted*] should have the following systems and equipment to operate in accordance with ETOPS:
  1. Both the airplane and engines should comply with all mandatory (or alert) service bulletins issued by the manufacturer.
  2. Electrical power.
     a. Three or more independent electrical power sources should be available, each of which should be capable of providing power to the following essential services:
        - i. Sufficient instruments for the flight crew providing, as a minimum, attitude, heading, airspeed and altitude information;
        - ii. Appropriate pitot heating;
        - iii. Adequate navigation capability;
        - iv. Adequate radio communication and intercommunication capability;
        - v. Adequate flight deck and instrument lighting and emergency lighting;
        - vi. Adequate flight controls;
        - vii. Adequate engine controls and restart capability with critical fuel-type (from the stand-point of flame-out and restart capability) and with the airplane initially at the maximum relight altitude;
        - viii. Adequate engine instrumentation;

ix. Adequate fuel supply system capability including such fuel boost and fuel transfer functions that may be necessary for extended duration single or dual engine operation;

x. Such warnings, cautions and indications as are required for continued safe flight and landing;

xi. Fire protection (engines and APU);

xii. Adequate ice protection;

xiii. Adequate control of the flight deck and cabin environment including heating and pressurization;

b. The equipment (including avionics) necessary for extended diversion times should have the ability to operate acceptably following failures in the cooling system or electrical power systems.

c. During one-engine inoperative operations, the 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 necessary for the overall safety of the passengers and crew. As a minimum, following the failure of any two of the three electrical power sources, the remaining source should be capable of providing power for all of the items necessary for the duration of any diversion. If one or more of the required electrical power sources are provided by an APU, hydraulic system or Air Driven Generator/Ram Air Turbine (ADG/RAT), the following criteria should apply as appropriate:

i. To ensure hydraulic power (Hydraulic Motor Generator) reliability, it may be necessary to provide two or more independent energy sources.

ii. The ADG/RAT, if fitted, should not require engine-dependent power for deployment.

d. Considering normal and abnormal modes, fuel boost and fuel transfer, the fuel supply system should be able to provide sufficient fuel for the entire diversion.

A.

b. **Certificate holder Requirements**.

i. **Operational Experience**:

1. As international operating experience typically involves long-range flights, prior to applying for authorization to conduct ETOPS a certificate holder must have at least 12 months experience operating a transport category turbine-engine powered airplane in international operations (excluding Canada and Mexico). Operations to or from the State of Hawaii may be considered as experience in international operations.
2. Certificate holders granted authority to operate under CFR Part 135 or Part 121 before [*insert date Part 135 rule is effective*] may credit up to 6 months of domestic operating experience (including Canada and Mexico) in a transport category turbojet airplane as part of the required 12 months of international experience. Domestic experience can be credited for part of the total 12 month requirement because the certificate holder has gained relevant operational experience in the airplane.
3. Operational experience requirements will not apply to certificate holders that have obtained ETOPS authority for other airplane types.

ii. **Training and Oversight**:

1. Certificate holders should ensure that all appropriate management personnel are aware of the unique and demanding nature of ETOPS.
2. Certificate holders should ensure that airplanes involved in ETOPS receive the highest feasible level of flight-following services.
3. Certificate holders must ensure that airplanes flown in accordance with ETOPS are maintained to required ETOPS standards and equipped according to ETOPS requirements.
4. Certificate holders should also ensure that airplanes flown in accordance with ETOPS are maintained and equipped according to recommended ETOPS standards and practices.
5. Certificate holders must ensure that flight crews and maintenance personnel involved in ETOPS are properly trained on all aspects of ETOPS.
6. Certificate holders must develop a Minimum Equipment List that reflects the unique aspects of ETOPS for each type of airplane operating in accordance with ETOPS.
7. The certificate holder shall ensure that flight crews are trained in their responsibilities, including passenger recovery, following an unscheduled landing.
8. In addition to the information required in 14 CFR Part 135.83, certificate holders shall ensure flight crews, both for preflight and during flight, have access to the most

current information available about possible ETOPS enroute alternate, destination and destination alternate airports to include:

a. Airports
    i. facilities (i.e.: snow removal, fuel availability, aircraft rescue and fire fighting capability)
    ii. navigation and communications aids
    iii. construction affecting takeoff, landing, or ground operations
    iv. air traffic facilities.
b. Runways, clearways, and stopways
    i. dimensions
    ii. surface
    iii. marking and lighting systems
    iv. elevation gradient
c. Displaced Thresholds
    i. location
    ii. dimensions
    iii. take off or landing or both

H. Certificate Holder Training Programs

a. **Flight Crew Training**: The certificate holder's flight crew training program should provide ETOPS training for flight crew members that includes, but is not limited to, the following areas:
    i. ETOPS regulations and advisory materials
    ii. Review of representative routes and airports within a ETOPS Area of Operation
    iii. Procedures for determining the ETOPS entry point and maximum distance allowed under ETOPS
    iv. Procedures for determining, prior to entry into a ETOPS Area of Operation, that critical systems and components are operating within normal parameters. Critical Systems and components that may affect the decision to enter into the ETOPS Area of Operation include, but is not limited to the following:
        1. Engines and powerplants
        2. Pressurization
            a. Dual sources of pressurization
            b. Automatic pressurization mode
        3. Oxygen - Sufficient supply for planned flight, and the impact oxygen endurance may have on fuel requirements

4. Auto flight system (if installed)
    a. Altitude hold
    b. Heading hold
5. Electrical systems

v. Airplane performance, including engine-out performance data, driftdown, engine-out service ceiling data and engine-out instrument approach procedures

vi. Flight preparation, planning and preflight:

1. ETOPS enroute alternate airport requirements
2. Procedures for selecting enroute alternates prior to a ETOPS flight
3. Conduct of a crew briefing for each ETOPS leg
4. Inflight procedures for updating weather forecasts and other reports of airport conditions.
5. Fuel/oil requirements at departure, including calculation of reserves required for:
    a. Identification of the most critical fuel-use scenario and most critical point for an diversion during a flight, considering possible one-engine failure and/or airplane depressurization with either all engines operating or one engine out.
    b. Uncertainty of long term terminal and enroute weather forecasts
    c. Uncertainty of enroute wind forecasts in remote areas.
    d. Possible navigational inaccuracy

vii. Flight progress monitoring, including fuel management procedures in the event a diversion is necessary for any reason

viii. Criteria for selecting appropriate ETOPS enroute alternate airports, both during flight planning and in flight, including the impact of enroute changes in weather forecasts and other operational conditions that may impact use of these airports

ix. Procedures and guidelines for making timely and appropriate diversion decisions and implementing appropriate diversion procedures, including:

1. Use of alternate navigation and communication systems, including flight management devices
2. Abnormal and emergency procedures to be followed in the event of equipment or systems failures during ETOPS, including:

a. Considerations for single, multiple and compounding (i.e.: one failure leads directly or indirectly to the failure of another piece of equipment) failures in flight that would precipitate a go/no-go and diversion decision. For example, if standby sources of electrical power significantly degrade cockpit instrumentation to the pilots, training should include considerations for flying an instrument approach with instruments powered only by an alternate source of electrical power.

b. Operational restrictions associated with equipment or component/systems failures, including restrictions associated with existing deferred maintenance items (Minimum Equipment List considerations).

c. Use of emergency equipment, including duration of time limited systems (battery, oxygen, fire extinguishing, etc.).

d. Procedures to be followed in the event a planned ETOPS enroute alternate airport is no longer acceptable.

x. Understanding of normal and abnormal/emergency procedures for additional or equipment modified specifically for ETOPS (modified oxygen systems, fuel systems, etc.).

xi. Fuel management procedures and monitoring/logging procedures to be followed during the enroute portion of the flight. These procedures should provide for an independent cross check (manual vs. automatic or pilot vs. copilot) of fuel quantity indicators. For example, fuel flows could be used to calculate fuel burned and compared to indicated fuel remaining (immediately follow previous fuel optimization procedures).

xii. If the flight crew may be required to perform any ETOPS pre-departure service or maintenance checks prior to departure on a ETOPS flight from an airport lacking ETOPS-trained maintenance personnel, such items should be included in flight crew training program.

xiii. Methods of maintaining position and situational awareness

xiv. Methods of determining the location of the nearest enroute alternate airports

xv. Use of plotting charts, both preflight and in flight

xvi. Responsibilities, including passenger recovery, following an unscheduled landing.

I. **11. Check Airman Used in ETOPS** Check airmen used by the certificate holder should ensure standardized flight crew practices and procedures are followed and also emphasize the special nature of ETOPS. In addition to the check airman qualification and training requirements of §135.337 and §135. 339, certificate holders should ensure that company check airmen understand the unique requirements of ETOPS.

J. **Maintenance Technician Training:** The ETOPS Maintenance Training Program should focus on the special nature of ETOPS maintenance requirements, and should be included in the accepted maintenance training curricula. The goal of this program is to ensure that all personnel involved in ETOPS are provided the appropriate training so that maintenance requirements are properly accomplished with regard to the unique nature of ETOPS. ETOPS qualified maintenance personnel are those who have successfully completed the operator's ETOPS training program.

K. **Fuel Planning.** An certificate holder should consider the following factors when determining the amount of fuel to carry onboard an airplane departing on a ETOPS flight:

a. **Factors that should be considered:**

    i. Current forecast winds and meteorological conditions along the expected flight path at the appropriate one engine inoperative cruise altitude and throughout the approach and landing.

    ii. Any necessary operation of ice protection systems and performance loss due to ice accretion on the unprotected surfaces of the airplane;

    iii. Any necessary operation of the Auxiliary Power Unit (APU), including APU oil consumption;

    iv. Loss of airplane pressurization; consideration must be given to flying at an altitude meeting passenger and crew oxygen requirements in the event of loss of pressurization;

    v. Holding for 15 minutes over the airport with a subsequent approach and landing.

    vi. Required navigational accuracy;

    vii. Any known air traffic control delays or restrictions.

b. No person may take off a flight for operations in ETOPS unless the fuel carried on board is the greater of :

    i. Fuel required under §135.223, or

    ii. Considering forecast wind and other weather conditions, the airplane carries sufficient fuel to complete the flight under the conditions outlined in (i) through (iv) below (Critical Fuel Scenario):

1. Greater of :
    a. Fuel sufficient to fly to a ETOPS enroute alternate airport assuming a rapid decompression at the most critical point followed by descent to a safe altitude in compliance with the oxygen supply requirements of §135.157.
    b. Fuel sufficient to fly to a ETOPS enroute alternate airport at the approved one engine inoperative cruise speed assuming a rapid decompression and a simultaneous engine failure at the most critical point followed by descent to a safe altitude in compliance with the oxygen supply requirements of §135.157; or
    c. Fuel sufficient to fly to a ETOPS enroute alternate airport at the approved one engine inoperative cruise speed assuming an engine failure at the most critical point followed by descent to the one engine inoperative cruise altitude.

2. Upon reaching the enroute alternate airport, hold at 1500 ft above field elevation for 15 minutes and then conduct an instrument approach and land.
3. The following additional factors should be considered:

Add a 5% wind speed factor (i.e., an increment to headwind or a decrement to tailwind) on the actual forecast wind used to calculate fuel in (i) above to account for any potential errors in wind forecasting. If a certificate holder is not using the actual forecast wind based on wind model acceptable to the FAA, allow 5% of the fuel required for a above, as reserve fuel to allow for errors in wind data. A wind aloft forecast distributed worldwide by the World Area Forecast System (WAFS) is an example of a wind model acceptable to the FAA. Other systems may be acceptable as well.

4. Compensate for the greater of :
    a. The effect of airframe icing during 10 percent of the time during which icing is forecast.
    b. Fuel for engine anti-ice, and if appropriate wing anti-ice for the time during which icing is forecast,

c. Unless the certificate holder has a program established to monitor airplane in-service deterioration of cruise fuel burn performance and includes in fuel supply calculations fuel sufficient to compensate for any such deterioration, increase the fuel supply by 5 percent to account for deterioration in cruise fuel burn performance.

d. If the APU is a power source required by this appendix, then its fuel consumption must be accounted for.

e. In computing the ETOPS alternate fuel supply, advantage may be taken of driftdown computed at the approved one engine inoperative cruise speed. Accounting of wing anti-ice as in §135.224(b)(iv)(B) may apply to some models of airplane based on their characteristics and the manufacturer's recommended procedures.

L. ETOPS Maintenance Program and Procedures

a. **General.** The premise of ETOPS is to preclude a diversion and, if it were to occur, to have programs in place that protect the operation of the diversion. ETOPS maintenance practices reduce diversions through disciplined procedures like engine condition monitoring, oil consumption monitoring, the aggressive resolution of reliability issues, and procedures that avoid human error during maintenance of airplane systems and engines.

Before flying ETOPS, a certificate holder must ensure that a ETOPS maintenance training is accomplished. The certificate holder may incorporate training for ETOPS requirements in its existing training program, or develop a separate ETOPS maintenance training program that complements its basic maintenance program and provides necessary training as appropriate.

The ETOPS maintenance program requires the certificate holder to ensure that its airplanes comply with the ETOPS configuration requirements as established during the type design approval for that airframe-engine combination, plus any additional airworthiness directives that may impact reliable ETOPS operation. Should an inflight engine shutdown occur, the certificate holder must immediately investigate and report the cause of the shutdown.

i. **Basic Maintenance Program.** The basic maintenance program for the airplane being considered for ETOPS is the certificate holder's continuous airworthiness maintenance program. Each airplane authorized to conduct ETOPS shall be maintained under such a program as provided in §135.411(a)(2). A maintenance program under §135.411(a)(1) which includes an inspection program under §135.419 may also be submitted to the Administrator for approval.

ii. **Additional ETOPS Maintenance Requirements.** The maintenance program should ensure that the airborne equipment continues to be maintained at the level of performance and reliability necessary for ETOPS. In addition to the basic, minimum continuous airworthiness maintenance program requirements, the certificate holder shall develop and utilize a maintenance program to include the following:

1. ETOPS Significant Systems Maintenance Requirements. The maintenance program should be reviewed by the FAA to ensure that all ETOPS significant systems are included within the certificate holder's maintenance program or have been incorporated in a ETOPS supplement to the certificate holder's maintenance program. A list of specific ETOPS maintenance significant systems should be identified for each engine/airplane combination. If recommended by the manufacturer, the certificate holder shall include oil consumption and engine condition monitoring within their maintenance program.

2. Oil Consumption Program: The certificate holder's engine/APU oil consumption program should reflect the manufacturer's recommendation and be sensitive to oil consumption trends. It should consider the amount of oil added at the departing ETOPS station with reference to the running average consumption (i.e., the monitoring should be continuous up to and including the oil added at the ETOPS departure station). If oil analysis is meaningful to this make and model, it should be included in the program. If the APU is required for ETOPS, it should be added to the oil consumption program.

3. Engine Condition Monitoring: This program should describe the parameters to be monitored, method of data collection, and corrective action processes. The program should reflect the manufacturer's instructions and industry practices. The goal of this monitoring program should be to detect deterioration at an early stage, and to allow for corrective action before safe operation is affected. Engine limit margins should be maintained so that a prolonged single-engine diversion may be conducted without exceeding approved engine limits (e.g., rotor speeds, exhaust gas temperature) at all approved power levels and expected environmental conditions. Engine margins preserved through this program should account for the effects of additional engine loading demands (e.g., anti-ice, electrical).

4. ETOPS Dual Maintenance Procedures. The maintenance program should include procedures which address ETOPS dual maintenance to preclude common cause human failure

modes. Whenever possible, these procedures shall preclude identical maintenance actions from being performed on the same element of identical, but separate ETOPS maintenance significant systems, during the same routine or non-routine visit. (NOTE: Servicing of fluids and gases is not considered multiple maintenance action.)

When ETOPS dual maintenance actions are performed, procedures should specify the use of adequate ground tests, separate maintenance technicians, Required Inspection Items, restriction of the airplane from ETOPS flights, a verification flight and/or other approved maintenance procedure to verify the airworthiness of maintenance actions prior to ETOPS. These procedures may include a preflight ETOPS checklist to be performed by the flight crew after unscheduled maintenance is performed at a location other than a maintenance base. This is to recognize and preclude common cause human failure modes without proper verification process or operation test prior to ETOPS.

5. <u>Verification Procedures</u>. Verification flights are accomplished after corrective action to a ETOPS significant system to identify potential human factors or mechanical errors prior to a ETOPS flight. Verification flights may be conducted on revenue flights provided that verification of the affected system is completed prior to the ETOPS Entry Point. The certificate holder should develop a verification program or procedures should be established to ensure corrective action following an engine shut-down (on twin engine airplanes), significant primary system failure, significant adverse trends, or any other prescribed event which require a verification flight or other actions, 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 certificate holder's program. Primary systems determined to be significant, or conditions requiring verification actions should be described in the certificate holder's ETOPS document.

6. <u>APU In-flight Start Reliability Program</u>. (if an APU is required for ETOPS) Each certificate holder is to establish a monitoring program in accordance with manufacturers' recommendations to ensure that the APU will continue at a level of performance and reliability established by the

manufacturer or the FAA. This monitoring program should include periodic sampling of APU in-flight starting capabilities.

iii. **Reporting Requirements.** In addition to the reporting requirements of §135.415, the certificate holder shall also report the following powerplant events to the airframe and engine manufacturers as well as to the Administrator.

a. Engine shut downs, both on ground and in-flight, (excluding normal training events) including flameout,
b. All occurrences where the intended thrust level was not achieved or where crew action was taken to reduce thrust below the normal level,
c. Unscheduled engine removals for maintenance
d. Operating hours and cycles for each engine and airframe.

2. The reports required should be submitted to the Principal Maintenance Inspector assigned to the certificate holder and the affected manufacturer on a quarterly basis and may be provided in an electronic format.

iv. **Propulsion System Monitoring and Corrective Action.** The certificate holder must conduct an investigation into the cause of each in-flight shut down (IFSD) in conjunction with manufacturers and submit findings to the Administrator. If the Certificate holder, Manufacturer, or Administrator determines that corrective action is necessary, the certificate holder must implement the corrective action. For all other reportable events required by §135.415 and paragraph (e) above, the certificate holder shall determine, after consultation with airplane and engine manufacturers and the Administrator, if corrective action is required. If the cause of an event is identified within a certificate holder's area of responsibility, the certificate holder shall take immediate corrective action.

Causes of IFSD's or other engine/propulsion system problems may be associated with type design problems, and/or maintenance and operation procedures applied to the airplane. It is very important to identify the root cause of events so that an indication of corrective action is available; a fundamental design problem requires an effective hardware (or software) final fix. Inspections may be satisfactory as interim solutions but longer term design solutions, i.e. terminating actions, are required if possible. Design problems can affect the whole fleet. A certificate holder that experiences a type -design related event, should not be operationally penalized by the Administrator for a problem that is design related and may not be of their making~~.~~ However, maintenance or operational problems may be wholly, or partially, the responsibility of the Certificate holder.

v. **Pre-departure checks**. Prior to departing for a flight where operation in accordance with ETOPS is planned, the certificate holder should ensure that all fluid levels, including oil, oxygen, fuel and hydraulics are checked by ETOPS trained personnel to ascertain they are at proper levels, and that caps and/or filler ports are properly closed/sealed. Flight crews may perform these pre-departure checks provided they have been properly trained. Whenever possible, no single person should perform pre-departure checks on the same ETOPS critical system or component.

vi. **Minimum Equipment List Considerations**: Considering the types of operations proposed, and equipment unique to the certificate holder, a certificate holder's MEL for ETOPS may be more restrictive than the MMEL. Certificate holders should be extremely aware of the issue of multiple deferrals and their significance on a long-range flight. Systems considered to have a fundamental influence on flight safety may include, but are not limited to, the following:

1. electrical, including battery;
2. hydraulic;
3. pneumatic;
4. flight instrumentation;
5. fuel;
6. flight control;
7. ice protection;
8. engine start and ignition;
9. propulsion system instruments;
10. navigation and communications;
11. auxiliary power unit
12. air conditioning and pressurization;
13. cargo fire suppression (Class D cargo compartments only)
14. engine fire protection;
15. emergency equipment;
16. any other equipment necessary for ETOPS.

M. Flight Planning

a. Time Limited Systems:

i. For ETOPS, the time required to fly the distance to the planned ETOPS alternate(s), at the all engines operating cruise speed, correcting for wind and temperature, may not exceed the time specified in the Airplane Flight Manual for the airplane's cargo fire suppression system time (if installed), minus 15 minutes.

ii. Except as provided in (a) above; for ETOPS, the time required to fly the distance to the planned ETOPS alternate(s), at the approved one engine inoperative cruise speed, correcting for wind and temperature, may not exceed the time specified in the Airplane Flight Manual for the airplanes most time limited system time (except for cargo fire suppression) minus 15 minutes.

iii. Certificate holders operating turbine-engine powered airplanes not meeting the requirements of a and b above as of the effective date of this regulation may continue ETOPS operations for a period not to exceed [*insert date that is eight years after Part 25 Appendix L is adopted]*.

iv. **Landing Distance.** For the runway expected to be used, the landing distance available must be sufficient based on Airplane Flight Manual (AFM) landing performance data to meet the landing distance limitations specified in FAR Part 135.385 or Part 135.393. The certificate holder should take into account the altitude of the airport, wind conditions, runway surface conditions and airplane handling characteristics.

b. **ETOPS Enroute Alternate Weather Minima**. Alternate weather minima standards specified in a certificate holder's operations specifications apply to both destination and enroute alternates. A summary of a typical certificate holder's operations specifications is reflected in the table below. An individual certificate holder's operations specification will reflect its current requirements.

[1] When determining the usability of an IAP, wind velocity plus gust must be forecast within operating limits, including reduced visibility limits.

[2] Conditional forecast elements need not be considered, except that a PROB40 or TEMPO condition below the lowest applicable operating minima should be taken into account.

[3] When departing using the provisions of the MEL, those MEL limitations affecting instrument approach minima should be considered in determining ETOPS alternate minima.

[4]For operations outside United States, due to variations in the international metric weather forecasting standards, 700m may be used in lieu of 800m

APPROACH FACILITY CONFIGURATION[1]	ALTERNATE AIRPORT IFR WEATHER MINIMUM CEILING[2]	ALTERNATE AIRPORT IFR WEATHER MINIMUM VISIBILITY[3]
For airports with at least one operational navigational facility providing straight –in non-precision approach procedure, or Category I precision approach, or, when applicable, a circling maneuver from an instrument approach procedure (IAP).	Add 400 ft to the MDA or DH as applicable	Add 1 sm or 1600m to the landing minimum
For airports with at least two operational navigational facilities, each providing a straight in approach procedure to different suitable runways.	Add 200 ft to the higher DH or MDA of the two approaches used.	Add ½ sm or 800m[4] to the higher authorized landing minimum of the two approaches used.
One useable authorized category III ILS IAP	200 feet	1/2 sm (800 m) or RVR 1800 feet (550 m)
One useable authorized category II ILS IAP	300 feet	3/4 sm (1200 m) or RVR 4000 (1200 m)

N. Flight Logging/Planning.

a. In addition to the requirements of §91.503, the certificate holder should ensure that the following information is available for use by the flight crew prior to departure:

   i. Planned route of flight
   ii. ETOPS entry/exit points
   iii. Planned enroute alternate airports
   iv. Equal time points
   v. Fuel consumption and expected use log
   vi. Flight progress reporting points

b. The pilot in command should have access to the weather and status of services and facilities at all adequate airports with weather greater than approach minimums other than the designated ETOPS alternates along the planned route that could be used for diversion prior to departure.

c. Potential Diversion Airports after Departure.

   i. After departure, designated ETOPS enroute alternate airports must remain at or above forecast operating weather minima. If the designated airports weather falls below operating minima, the flight crew must designate new ETOPS enroute alternate airports within the ETOPS diversion limit that meet appropriate operating weather minima.

   ii. The pilot or certificate holder should monitor the airports within the ETOPS area of operation that could be used for diversion for deterioration in the weather and limitations in the availability of facilities and services that would render an airport unsuitable for landing in the event of a diversion. If this monitoring is done by the certificate holder, a reliable method of communication with the airplane must be readily available.

   iii. During the course of the flight, the flightcrew must be aware of significant changes in conditions at the designated ETOPS alternates, particularly those conditions that would render an airport unsuitable for landing and improvement in airport weather to conditions above operating minima.

   iv. Before a ETOPS flight proceeds beyond the ETOPS entry point, the weather during the expected times of arrival at the designated ETOPS alternates, as well as the landing distances, airport services, and facilities should be evaluated. If any conditions such as weather below landing minima are identified that would preclude a safe approach and landing, the pilot should select additional ETOPS alternate(s) where a safe approach and landing can be made. The maximum diversion time determined by the newly selected ETOPS alternate(s) should not exceed 240 minutes (in still air)

d. The pilot in command should consider all relevant factors in determining the suitability of an airport. The following factors and others may be relevant in determining whether an airport is suitable or not:
   i. Airplane configuration / weight / systems status / fuel remaining
   ii. Wind and weather conditions en route at the diversion altitude
   iii. Minimum altitudes en route to the diversion airport
   iv. Fuel burn to the diversion airport
   v. Airport nearby terrain, weather and wind
   vi. Runways available and runway surface condition
   vii. Approach navaids and lighting available
   viii. Availability of crash, rescue and firefighting equipment
   ix. Facilities for passenger and crew disembarkation and accommodations
   x. Pilot's familiarity with the airport

e. When operating a two engine airplane with one engine inoperative, none of the following factors should be considered sufficient justification to fly beyond the nearest suitable airport:
   i. The fuel supply is sufficient to fly beyond the nearest suitable airport
   ii. Passenger accommodations, other than passenger safety
   iii. Availability of maintenance / repair resource

O. System Failures / Partial Failures

a. If, as a result of reevaluating airplane systems, a change in flight plan is required, the pilot shall revise the flight plan information based on the conditions, including weather conditions, at designated ETOPS alternates.

P. Applying for ETOPS

Each certificate holder requesting approval to conduct ETOPS should have appropriate operational experience, including sufficient maintenance and operation familiarity with the particular airframe-engine combination. Appropriate operational experience involves conducting long-range flights (beyond 60 minutes) up to 180 minutes that require more complex flight planning and careful execution in areas where operating alternatives are limited, should an in-flight diversion be required.

14 CFR Part 135, Appendix G states that prior to conducting ETOPS, a certificate holder shall have at least 12 months operating experience with a type of transport category turbine-engine powered airplane conducting international operations (excluding Canada and Mexico), including operations to or from the State of Hawaii. Existing certificate holders on *[insert effective date of rule]* may credit up to 6 months of domestic operating experience (including Canada and Mexico) in a transport category turbojet airplane as part of the required 12 months of international experience. After obtaining ETOPS

authorization for one airplane type, a certificate holder may add additional ETOPS capable airplanes to its operations specifications without additional operating experience.

Before a certificate holder is granted operational approval, its capability to conduct operations and implement effective ETOPS programs in accordance with the criteria detailed in this AC will be examined by the FAA. Only certificate holders who have demonstrated capability to conduct long range flights will be considered for approval. The flights conducted under ETOPS authority will be limited to a maximum diversion time of 240 minutes from an enroute alternate airport, at a speed selected by the certificate holder from a range of speeds approved by the FAA that is within the certificated operating limits of the airplane, with one engine inoperative (under standard conditions in still air).

The unique nature of long range operations necessitates an evaluation of these operations to ensure that the certificate holder's proposed programs are effective. To the extent that changes in the certificate holder's continued airworthiness and operations program are required as a result of this evaluation, they are to be approved through the normal approval processes. The FAA will review the certificate holder's documentation and training programs to validate that they are appropriate for ETOPS. Each certificate holder applying for ETOPS approval must demonstrate the ability to continuously maintain and operate the particular airframe systems and engine at levels of reliability appropriate for the intended operation. The certificate holder must also show that it has trained its personnel to achieve competency in ETOPS. The certificate holder should show compliance with the flight operations and maintenance requirements of this AC.

A certificate holder requesting approval for ETOPS should submit the request, with any required supporting data, to the certificate-holding district office at least 60 days before the proposed start of ETOPS operations. The certificate holder's application should address the following topics: (See Appendix 1 for an application checklist)

a. **Airplane:** The applicant should list the specific make and model of airplane and engine and the airplane serial and registration numbers to be used in ETOPS.

    i. **Airplane Performance:** The altitudes and airspeeds used for establishing the ETOPS entry point for each airframe-engine combination must be shown to permit compliance with the terrain and obstruction clearance requirements of 14 CFR 135.364 and 14 CFR 135.181(a)(2).

    ii. **Minimum Equipment List (MEL)** The certificate holder is required to submit an MEL, or revision to its MEL, developed in accordance with the MMEL, appropriate to ETOPS. Systems considered to have a fundamental influence on flight safety may include, but are not limited to the following:

        1. Electrical, including battery

2. Hydraulic
3. Pneumatic
4. Flight instrumentation
5. Fuel
6. Flight control
7. Ice protection
8. Engine start and ignition
9. Propulsion system instruments
10. Navigation and communications
11. Auxiliary power-unit
12. Air conditioning and pressurization
13. Cargo fire suppression (class D compartments only)
14. Emergency equipment
15. Any other equipment necessary for ETOPS

b. **Communication and Navigation Facilities** As per § 135.165, the certificate holder must demonstrate the availability of two-way communication during diversion at anticipated diversion altitudes.

c. **Training:** The certificate holder should document that it has incorporated ETOPS training into its crew training programs, and that personnel conducting ETOPS training are properly qualified.

d. **Passenger Recovery Plan** The certificate holder should ensure that flight crews are trained in their responsibilities, including passenger recovery, following an unscheduled landing. The recovery plan should address the safety and well being of passengers and crew at the diversion airport and include a plan to transfer the passengers and crew from that airport safely and without undue delay.

Q. Operational Approval Process

For certificate holders seeking ETOPS authority for the first time, the application and supporting data, along with the certificate-holding district office's principal inspectors' (Principal Maintenance Inspector, Principal Avionics Inspector and Principal Operations Inspector) recommendations are to be forwarded to the Director, Flight Standards Service, for review and concurrence. The Director should either authorize ETOPS or state the additional requirements necessary to gain ETOPS authorization. When authorized by the Flight Standards Director, operations specifications authorizing ETOPS will be issued to the certificate holder by the CHDO.

For certificate holders that have existing ETOPS authority, the application and supporting data should be forwarded to the certificate-holding district office for approval. Operations specifications authorizing additional ETOPS airplanes or areas of operation will be issued to the certificate holder by the CHDO.

As a minimum, operations specifications for ETOPS should provide the following authorizations and limitations:

a. Approved airframe-engine combination(s)
b. Current approved CMP standard required for ETOPS, if appropriate

c. ETOPS area(s) of operation
d. Approved maintenance and reliability program for ETOPS including those items specified in the type design approved standard, if appropriate
e. Identification of the airplanes authorized for ETOPS by make, model and serial and registration number

R. ETOPS Validation Testing: Prior to granting initial ETOPS authorization, the FAA may require validation testing to demonstrate the certificate holder's ability to safely conduct ETOPS. Validation testing may be included as part of a certificate holder's airplane proving test as required by §135.145. Validation testing can include evaluation of the certificate holder's policies and procedures, systems and, where practical, flight simulation or table top simulation. In some cases, a validation flight may be required. If required, a validation flight can be included in proving flights and can be flown using representative ETOPS routes. The Director, Flight Standards Service, will determine the conditions for each certificate holder's validation testing following a review, on a case-by-case basis, of the certificate holder's experience and the proposed operation. In the event a proving test did not include ETOPS validation, the certificate holder shall notify their CHDO at least 7 days prior to conducting the first ETOPS flight to allow the FAA to monitor the operation.

NOTE: Validation flights may not be required for certificate holders that meet the operating experience requirements of Part 135, Appendix G, Paragraph A.

S. Continuing Surveillance

The certificate holding district office (CHDO) may initiate a special evaluation, which may result in the imposition of any prudent operational restriction necessary, and corrective action required of a certificate holder in order to resolve problems in a timely manner. If any problem associated with airplane design is identified, the CHDO should notify the Aircraft Certification Office (ACO) responsible for type design approval.

T. COMMENTS INVITED

U. HOW TO ORDER

Appendix 1: ETOPS APPLICATION CHECKLISTS

A. The following checklists are provided to facilitate the application for ETOPS approval.

1. Maintenance Application Checklist

a. Date of type design of each engine and airframe.

b. Certificate holders experience for requested engine / airframe combination:

(i) Show number of months / years of operational experience with the specific engine / airframe combination.

(ii) Show the total number of international (excluding Canada and Mexico) flights with the specific engine / airframe.

(iii)Total engine and airframe hours and cycles:

(a) In-flight engine shutdowns (all causes):

(b) Mean time between failures (MTBF) for ETOPS critical systems/components – if available.

(c) Record of APU start and run reliability if the APU is an essential power source for ETOPS

(d) Record of significant certificate holder events:

i. Uncommanded power changes (surge or roll back)

ii. Inability to control engine or obtain desired power

iii. Total number of in-flight shutdown events.

(iv)ETOPS Maintenance Requirements

(a) Supplemental ETOPS Maintenance Program

(b) ETOPS Maintenance Manual

i. Should be identified as a chapter in the general maintenance manual

ii. The manual should be submitted to FSDO 60 days before the implementation of ETOPS flights.

iii. When practical, preclude identical action being applied to multiple similar elements in ETOPS critical system. (e.g., fuel control change on both engines), or develop human-factors safeguards.

iv. ETOPS tasks should be identified on routine work forms and instructions.

v. ETOPS procedures should be clearly defined in maintenance program, such as:

(c) ETOPS service check should be developed

1. Verify the airplane status and ensure that certain critical items are acceptable.
2. This check should be signed off by an ETOPS qualified person

(d) Oil Consumption Program

i. Should reflect manufacturers' recommendations
   1. Sensitive to oil consumption trends
   2. Record the amount at departure stations
   3. Monitor running average consumption.
   4. SOAP samples, if meaningful to make and model
   5. APU should be added to the program

(e) Engine Condition Monitoring

i. Describe the parameters to be monitored.
ii. Method of data collection
iii. Corrective action process
iv. Purpose to detect deterioration at an early stage

(f) Resolution of Airplane Discrepancies

i. Verification program to ensure corrective action following:
   1. Engine shutdown
   2. Primary system failure
   3. Adverse trends or any events, which require verification flight (or other action to assure there accomplishment)
ii. A clear description of who must initiate verification actions and the section responsible for the determination of what action is necessary
iii. Primary systems (APU)
iv. Conditions requiring verification actions should be described in the maintenance manual

(g) Reliability Program

i. Should be event oriented
ii. Incorporate reporting procedures (72 HRS) for significant events detrimental to ETOPS
iii. In addition to the items in mechanical reliability reports, the following are included:
   1. In-flight shutdowns

2. Diversion or turnback
3. Uncommanded power changes or surges
4. Inability to control the engine or obtain desired power
5. Problems with systems critical to ETOPS
6. Any other event detrimental to ETOPS

iv. The report should identify the following:

1. Airplane identification (make and "N" number)
2. Engine identification (make and serial number)
3. Total time, cycles and time since last shop visit
4. For systems: TSO or last inspection of the unit
5. Phase of flight
6. Corrective action

(h) Propulsion System Monitoring (IFSD)

i. Process for investigating all IFSD events

(i) Maintenance Training

i. Focus on special nature of ETOPS and maintenance requirements

(j) ETOPS Parts Control

i. Ensures proper parts and configuration are maintained for ETOPS

ii. Verification that parts placed on ETOPS airplanes during parts borrowing or pooling arrangements are ETOPS-applicable

iii. In addition to those parts used after repair or overhaul

Appendix 2: ETOPS APPLICATION CHECKLIST– OPERATIONS

A. Operating experience for each airframe / engine combination: (Note: The data for this item may be submitted in the maintenance portion of the application.)

B. International flight experience (excluding Canada and Mexico)

C. Performance chart(s), range of single engine inoperative speeds and altitude capability charts which are used to calculate the ETOPS entry point and distance equivalent of 240 minutes.

D. Indicate how flight planning will consider terrain clearance along planned routes (including enroute alternate airports) based on selected range of single-engine speeds**.**

- **1.** The airspeed used to calculate the area of operations should be used in evaluating obstacle clearance;
- **2.** NET performance data should be used;
  - a. Maximum possible diversion gross weight should be used;
  - b. Plus 10 temperature deviation should be used;
  - c. Wing and engine anti-ice should be assumed to be OFF;
  - d. Advantage may be taken of drift down from cruise altitude to single engine inoperative cruise altitude

E. Indicate how crews will be provided a plotting chart showing the area of operations for each ETOPS flight. (Diversion distance circles should be plotted from enroute alternates used to calculate the area of operations.)

F. Indicate how ETOPS enroute alternates will be selected so as to:

- **1.** Indicate compliance with landing distances, services, and facilities.
- **2.** Consider enroute alternate minimums and crosswind components in selection of enroute alternates.

G. Show maximum crosswind component used for ETOPS alternate selection prior to takeoff.

H. Ensure enroute alternate minimums comply with Ops Specs paragraph C055.

I. Show compliance with evaluation of alternate conditions during the en-route phase.

J. Copy of MEL showing compliance with MMEL. (For each Airframe / engine combination, if necessary.)

K. Sample copy of:

- **1.** Flight plan
- **2.** Plotting chart

L. Show how crews will determine the adequacy of communication and navigation services

M. Airplane Performance Data: For each Airframe / engine combination show operations manual pages used to comply with ETOPS requirements

N. Demonstrate how crews will comply with the ETOPS fuel and oil requirements

O. Flightcrew Training and Evaluation Program:

- **1.** Show where flight crew training items identified in Section 14 of this AC are covered

2. Show that any training issues, if appropriate, identified in the Flight Standardization Board (FSB) have been incorporated in the training program.

P. Show how crews will obtain required weather information for ETOPS

Q. Equipment required by Part 135.165 and Appendix G

R. Plan for ETOPS Validation Testing (if required):

1. Proposed dates

FAA Action: NPRM FAA-1999-6717; Final rule FAA-2002-6717