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July 30, 1999

U.S. Department of Transportation Dockets
Docket No. FAA-1999-5401 -22
400 Seventh St. SW., Room Plaza 401
Washington, DC 20590

PROPOSED RULE: Aging Airplane Inspections/Adoption of Damage Tolerant Criteria

Gentlemen/Madam:

The Regional Airline Association (RAA) submits the following comments to the subject proposed rule on behalf of its membership (attachment A). RAA encouraged its members to submit comments directly to the docket. RAA comments should be considered as supplemental to any comments individually submitted to the docket by RAA members.

The high costs associated with complying with the proposed rule will be disproportionately borne by operators of fleets with non damage tolerant airplanes; yet the service experience for such fleet types, particularly for the regional and commuter airplanes, does not justify the high cost of converting to a damage tolerant inspection program. RAA members and the regional/ commuter airplane OEM's who served on ARAC's Small Transport/Commuter Airplane Airworthiness Assurance Working Group (SAAWG), devoted a significant number of manhours over a two year time period in developing an alternate aging airplane inspection program for non-damage tolerant airplanes; yet the proposed rule fails to mention their efforts or why their program was rejected. RAA remains convinced that a rule based upon the efforts of the ARAC working group will more effectively address the safety concerns associated with aging airplanes than the FAA proposal.

ALL PROVISIONS OF FAA NOTICE 99-02 SHOULD BE WITHDRAWN

All provisions of Notice 99-02 should be withdrawn for the following reasons:

1. **Notice 99-02 does not carry out the significant provisions of the "Aging Aircraft Safety Act of 1991" (Act).**

   - The Act requires *the Administrator* to make the inspections, Notice 99-02 delegates that responsibility to the DAR's (in whole or in part). We would assume that the inspections would be comparable to that of a FAA NASIP (or ATOS) inspection of the air carriers, yet the FAA has never considered delegation of NASIP inspections.
   - The Act directs the FAA to conduct the inspections and (record) reviews *as part of each heavy maintenance check of the aircraft conducted after the 14th year in which the*

aircraft has been in service. Notice 99-02 establishes 5 year intervals of inspections and provides for a deadline of a 90 day extension beyond the 5 year interval. Should the air carrier through no fault of its own, not have the review within these fixed compliance periods then under Notice 99-02, the airplane cannot be "operated". The Act by specifying that the inspection be *apart of each heavy maintenance check,* clearly sought not to be disruptive to an air carrier's current maintenance program, yet Notice 99-02 will unequivocally change each carrier's maintenance program to fit the rule at considerable cost to the air carrier. While we can understand the FAA's proposal to deviate from the Act to allow a reasonable phase in period for airplanes that have already achieved their 14^{th} year of service, the FAA clearly has no mandate from the Act to construct a 5 year heavy maintenance check schedule and a 90 day extension deadline.

- Proposed FAR 121.368 (also 135.422) uses the term "highest degree of safety" to describe whether maintenance is adequate and timely. This term is of course, also found in the FAA Aviation Act of 1958 yet it has never appeared in a rule (FAR) until now. We believe the FAA should interpret the Act and not simply plug in the same phrase into a regulation. An air carrier has to know how to comply with a rule and the term "highest degree of safety" has different meanings for different people. In the case of trying to describe parts and components found on older airplanes, the phrase "highest degree of safety" might mean the use of all brand new parts, yet that would clearly be illogical simply because an airplane has been in operation for 14 years. The phrase was never meant to be in a rule and should not be used.
- Both the record review/inspection and supplemental inspection provisions use the phrase "no certificate holder (person) may operate an airplane unless". While this phrase is used frequently in Subpart K, Part 12 1 to describe equipment that must be installed on an airplane, the phrase is not used in Subpart L, Part 121 to describe the requirements of a maintenance program. We view this distinction in use of the term between subparts as significant since a FAA inspector can readily determine whether equipment is installed on an airplane by inspecting an airplane; however a record inspection would be required to verify compliance with a particular maintenance program. The phrase in this instance is misused.

2. The "Aging airplane records reviews and inspections" provisions (FAR 121.368, 129.33, 135.422) are completely redundant to current inspections.

- Operators are currently required by regulation to maintain all of the information that would be derived from the proposed record review and inspection provision. Since the FAA now has complete authority to determine whether any operator has deficiencies in its maintenance program, the proposed rule must be viewed as redundant to current rulemaking. The operators continue to work cooperatively with the FAA and the OEM's in resolving airworthiness concerns associated with aging aircraft. One recent example are the FAA/industry meetings held to develop the various AD's for requiring additional shop inspections for engine rotating components. A previous example is of course the efforts of the ARAC SAAWG. Operators <u>expect</u> to adopt additional inspection requirements for airplanes that have been in operation for more than 14 years. RAA members support the adoption of AD's that provide for enhanced structural integrity inspections for the specific airplane type. What regional operators will not support are rules that simply duplicate existing rules and FAA inspection programs.

- The proposal to have FAA or a DAR conduct a record review and determine the airworthiness of every aging airplane is totally impractical and unprecedented; FAA inspectors and the current DAR's simply do not exist in sufficient numbers to adequately support such a program. This would also be the first regulation where someone other than the operator is "responsible" for the airworthiness of the air carrier's airplanes. The proposed rule confuses the FAA's oversight responsibilities with that of an air carrier's responsibility for the airworthiness of its aircraft; that responsibility obviously does not stop when aircraft achieve 14 years in service.
- The concept that the FAA or a designee first review the records and conduct inspections on an air carrier's airplanes and that the air carrier could not operate the airplanes until the review and inspection is complete goes beyond the normal role of the FAA as an overseer of the air carriers. The air carrier is placed into a position of dependency with the FAA or its designee in order to meet its operational schedule and the reasons. We can certainly understand an aircraft being removed service for reasons of airworthiness but an aircraft should not be grounded simply because may achieve a certain service life milestone and there is no-one available or willing to check on some paperwork. This smacks of a bureaucratic nightmare. Nick Lacey of the FAA was recently quoted in Aviation Weekly (May 24th) as stating that NASIP's, a similar program of record review and inspection, have not worked well. "When I look back on NASIP since its inception in 1986, it has caused more headaches inside and outside government that it has solved problems." What guarantees does industry have that the "aging aircraft inspections" will not be less productive than a NASIP inspection?

3. **The "Supplemental inspections" provisions (FAR's 121.370a, 129.16, 135.168) to adopt only "damage tolerant" programs is arbitrary since there are equivalent programs to validate the integrity of airplane structure.**

- The supposition that only a damage tolerant based maintenance program can guarantee structural integrity simply cannot be technically justified. For the smaller airplanes cited in the proposed rule the FAA has not referenced any technical basis for rejecting the alternate inspection program submitted by ARAC SAAWG. For certain principal structural elements, a damage tolerant analysis may indeed be the most realistic analysis; but for other PSE's may be more appropriate. To suggest however that a damage tolerant analysis must be conducted on all structure elements regardless of service experience is technically unsound.

4. **The "Supplemental inspections" provisions (FAR 121.370a, 129.16, 135.168) that allow certain airplanes (with AD mandated SSIP programs) to operate until December 20, 2010 without a "damage tolerant" programs discriminates against operators of the regional airplanes that have equivalent structural inspection programs but are simply not mandated by SSIP AD's.**

- An operator that may have an equivalent supplemental inspection program but that is not mandated by a SSIP AD, must comply with the damage tolerant requirements as early as

4 years after the effective date of the proposed rule even though the age of their airplane is considerably less than the SSIP AD mandated airplanes . We view the difference in compliance time period that is based upon whether the structural maintenance program is based upon whether an AD exists or not, as lacking in technical merit.

- For many of the airplane types, the compliance schedule for airplanes with SSID mandated AD's is arbitrary against there may be airplane fleet types that are in the process of qualifying for an approved SSID AD program after Notice 99-02 is adopted but for whatever reason the AD was not adopted until after the adoption of Notice 99-02.
- Most of the SSIP airplanes are considerable older than the regional airplane types that are cited in the proposed rule as having non-damage tolerant maintenance inspection programs. While we recognize that a ongoing SSIP program provides additional assurance of structural integrity, it must also be acknowledged that for the affected regional/commuter airplane types without SSIP AD's, the service experience for demonstrating structural integrity has been excellent.
- Several regional/commuter OEM's report that they have submitted structural integrity programs to the FAA as early as 1990 yet the FAA has not adopted the AD's to mandate changes to the affected operator's maintenance programs. What is the technical basis for granting certain operators the opportunity for extended compliance schedules when other less fortunate operators have equivalent inspection programs in place but the FAA has seen fit not to write an AD?

5. **The information provided by the proposed FAR 12111291135 Appendix can be obtained from other sources and is therefore redundant. It will likely conflict with other FAA approved certification documents unless it is constantly updated and corrected. The Appendices to the regulations were not meant to be a repository for aircraft certification records.**

- A number of the design goals provided are inaccurate and once adopted, would need constant revision. RAA has been advised by several foreign based airframe OEM's that the proposed fatigue lives for their fleet types are inaccurate; that extensions have been approved by foreign regulatory authorities. We suspect that these differences will not all be reflected in the adopted rule and that subsequent rulemaking changes will be necessary.
- The design life goals don't take into account the difference in design goals that exist between the various aircraft structure -e.g. wings, fuselage, vertical and horizontal stabilizers, etc. A rule that provides for just one design goal when the airplane was certified to several design goals for the aircraft structure would have to be viewed as arbitrary.

6. **The Cost/Benefit Analysis is inadequate.**

- The analysis states that "the FAA is unable to quantify the expected benefits of the proposal on the basis of historical accident rates that would be reduced." The analysis states further that the FAA is unable to determine the critical aspects of air transportation safety as the affected airplanes age and that absent this ability the FAA would be forced to retire these aircraft as some arbitrary age. Again the FAA does not address why the alternate inspection program presented by the ARAC SAAWG is inadequate. Presidential Executive Order 12866 directs the FAA to assess the "costs and benefits of potentially effective and reasonably feasible alternatives to the planned regulation and (provide) an explanation why the planned regulatory action is preferable to the identified potential alternative". Absent a discussion and a comparison of costs in implementing the ARAC SAAWG program versus the proposed damage tolerant program, we view the cost benefit analysis as inadequate and in need of rework.

THE ARAC WORKING GROUP PROPOSAL SHOULD BE ADOPTED INSTEAD OF FAA NOTICE 99-02

RAA requests the following:

1. **Remove all of the FAR 121/129/135 provisions in Notice 99-02 and replace with the following provisions:**

   Damage-tolerance or structural integrity inspections (FAR 12 1 /129/1 3 5):

(a) Each certificate holder shall incorporate within its maintenance program either a damage-tolerance-based or structural integrity inspection program for each airplane operated by the certificate holder. The damage-tolerant or structural integrity inspection program must be approved by the FAA Aircraft Certification Office (ACO) having cognizance over the type certificate for the affected airplane. Compliance with this provision shall be required:

> (1) For an airplane that has exceeded 24 years in service on [the effective date of the rule], no later than [3 years after the effective date of the rule]; or
> (2) For an airplane that has exceeded 14 years in service but not 24 years in service on [the effective date of the rule], no later than [5 years after the effective date of the rule]; or
> (3) For an airplane that has not exceeded 14 years in service on [the effective date of the rule], no later than 5 years after the start of the airplane's 15th year in service.

2. **RAA requests that the ARAC Advisory Circular, dated June 1994, as amended (Attachment B) be referenced in the supplemental information for the final rule as an acceptable means of compliance for establishing a FAA approved structural integrity program.** The preamble to NPRM 99-02 states that draft AC 9 1 -MA "Continued Airworthiness of Older Transport and Commuter Airplanes; Establishment of Supplemental Inspection Programs" provides guidance for developing an acceptable damage-tolerant based inspection program. This title is also referenced in draft AC 120-XX. However the version of draft AC 9 1 -MA that is downloaded from the FAA web site is titled "Continued Airworthiness of Older Small Transport and Commuter Airplanes; Establishment of Damage-Tolerance Based Inspection and Procedures" While the change in title may just be an editorial error, it would appear that the FAA decision to specify a damage-tolerance based program as the only method of compliance, is a last minute decision. The original draft AC 9 1 -XX that ARAC SAAWG submitted to the FAA in June, 1994, was titled "Continued Airworthiness of Older Small Transport and Commuter Airplanes; Establishment and

Extension of Operational Limits". The ARAC SAAWG draft AC 91 -XX serves as the basis for draft AC 9 1 -MA but with significant revision accomplished by the FAA without industry coordination. RAA proposes that our earlier AC serve as the basis for our alternate structural integrity inspection program. The earlier AC needs revision to replace the term "operational limit" with "thresholds for inspection".

- At the time ARAC submitted the AC to the FAA, it was noted that the Technical Oversight of Aging Aircraft (TOGAA) group took exception to one paragraph of the AC (Appendix C). Appendix 1, Section 5a (2)(ii) of the ARAC AC did not receive the endorsement of TOGAA because "it permitted a (threshold) to be established for single load path structure using Minor's Rule without comparative crack growth evaluation for equivalent reliability" RAA believes that this one difference between ARAC SAAWG and TOGAA recommendations can be resolved to the satisfaction of the FAA. But in order to successfully resolve this one difference, the proposed rule must be revised to allow an alternate to a damage tolerant based inspection program, as it would be apply for single load path structure.

3. While Notice 99-02 provisions didn't reference "repairs", the preamble states that "FAA approved major structural repairs should be analyzed in the same manner as modifications accomplished under an STC"; or in other words, major repairs and whether the repairs were accomplished using a damage tolerant based methodology, will be considered as part of the adopted rule. **RAA requests that the review of "repairs" be specifically excluded from the adopted rule (on aging aircraft) and that the FAA reissue the Structural Repair Assessment Program NPRM (Notice 97-16, dated 1/2/98) as a supplemental notice (SNPRM) expanding the applicability to all FAR Part 121 airplane types that were not certified to damage tolerant criteria.** FAA Notice 97- 16 proposed that a repair assessment program be accomplished on certain large transport airplane types (e.g. Boeing Airbus, Lockheed and Fokker airplanes). It affects only the fuselage pressure boundary structure (fuselage skins and pressure webs). Notice 99-02 proposes a major repair review of the entire structure for all airplane types. **Before the SNPRM is issued, RAA requests that the FAA conduct a series of public meetings so that operators and airframe OEM's who were not previously affected, could participate and understand the referenced documents of this NPRM.** The regional airline industry should also be given the opportunity to revise the advisory documents (or create a companion document) that is specifically written for their airplane types before the SNPRM is issued.

Your consideration of the comments and requests of RAA and its member's, is appreciated.

Sincerely,

David Lotterer

David Lotterer
Vice President - Technical Services

Attachments

ATTACHMENT A

Company	City, State
Aeromar	Mexico City, DF*
Air Midwest	Wichita, KS
AirNet Systems	Columbus, OH
Air Nova	Enfield, Nova Scotia, Canada*
Air Ontario	London, Ontario*
Air Serv	Redlands, CA
Air Wisconsin	Appleton, Wis
Allegheny	Middletown, PA
American Eagle	Dallas, TX
Atlantic Coast Airlines	Dulles, VA
Atlantic Southeast	Atlanta, GA
Austin Express	Austin, TX
Big Sky Airlines	Billings, MT
Business Express	Dover, NH
Cape Air	Hyannis, MA
CCAIR	Charlotte, NC
Champlain Air	Plattsburgh, NY
Chautauqua Airlines	Indianapolis, IN
Colgan Air	Manassas, VA
Comair	Cincinnati, OH
CommutAir	Plattsburgh, NY
Community Air	Ukiah, CA
Continental Express	Houston, TX
Corporate Air	Billings, Montana
Corporate Express	Nashville, TN
Eagle Aviation	Las Vegas, NV
Empire Airlines	Coeur d'Alene, ID
ERA Aviation	Anchorage, AS
Executive Airlines Inc.	San Juan, P.R.
Executive Airlines	Farmingdale, NY
Express Airlines I	Memphis, TN
Falcon Express	Tulsa, OK
Federal Express	Memphis, TN
First Air	Dallas, TX
Grand Canyon	Grand Canyon, AZ
Great Lakes Aviation	Bloomington, MN
Gulfstream Int'l	Miami Springs, FL
Horizon Air	Seattle, WA
Island Air	Honolulu, HI
Kitty Hawk Air Cargo	DFW Airport, TX
Mesa Air Group	Phoenix, AZ
Mesaba	Minneapolis, MN

Company	City, State
Midway Airlines	RDU Int'l Airport, NC
Ozark Airlines	Columbia, MO
Pan Pacific	Mount Vernon, WA
Piedmont Airlines	Salisbury, MD
PSA Airlines	Vandalia, OH
Scenic Airlines	N. Las Vegas, NV
Seaborne Aviation	Christiansted, USVI
Servicios Aereos Litoral	San Antonio, TX *
Sedona (Aaron)	Seattle, WA
Shuttle America	Windsor Locks, CT
Skymark	Spokane, WA
Skyway Airlines	Oak Creek WI
Skywest	St. George, UT
Sunworld Int'l Airlines	Ft. Mitchell, KY
Tie Aviation	Jamaica, NY
Triton Air	Mesa, AZ
UFS	St. Louis, MO
Universal Airways	Houston, TX
Walker's Int'l	Ft. Lauderdale, FL
Wiggins Airways	Norwood, MA
Wings Airways	Blue Bell, PA

* foreign based air carrier

ATTACHMENT B

U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

DRAFT WORKING MATERIAL--
NOT FOR PUBLIC RELEASE

Subject: CONTINUED AIRWORTHINESS OF OLDER SMALL TRANSPORT AND COMMUTER AIRPLANES; ESTABLISHMENT AND EXTENSION OF OPERATIONAL LIMITS

Date: JUN 1 3 1994
Initiated by: ACE-100

AC No: 91-XX
Change:

1. PURPOSE. This advisory circular (AC) provides information and guidance regarding an acceptable means, but not the only means, of showing compliance with the operational requirements of the Federal Aviation Regulations (FAR) applicable to the establishment of Operational Limits and the extension of the Operational Limit. It is for guidance purposes and provides an example of a method of compliance that has been found acceptable. Because the method of compliance presented in this AC is not mandatory, the terms "shall" and "must" used in this AC apply only to an applicant who chooses to follow this particular method without deviation. The applicant may elect to follow an alternate method provided the alternate method is also found acceptable by the FAA. This advisory circular provides guidance for fleet-wide limits. Individual operators seeking limits different than the fleet-wide limits may use this guidance in support of their application.

2. APPLICABILITY. The following guidelines are intended for use in setting and extending Operational Limits for:

a. airplanes of less than 75,000 pounds maximum certified takeoff weight, which are used in scheduled air carrier or commuter service; and

b. the airplane type is not certified to damage tolerance criteria; and

c. the airplane type does not have an approved supplemental inspection program or equivalent.

3. RELATED REGULATIONS AND DOCUMENTS.

a. Regulations.

§ 121.212 - Aging Airplane Limitation

§ 129.20 - Aging Airplane Limitation

§ 135.168 - Aging Airplane Limitation

b. Advisory Circulars. The AC's listed below may be obtained from the U.S. Department of Transportation, General Services Section, M-443.2, Washington, DC 20590:

AC 25.571-1A	Damage-Tolerance and Fatigue Evaluation of Structure
AC 91-56	Supplemental Structural Inspection Program for Large Transport Category Airplanes
AC 91-60	Continued Airworthiness of Older Airplanes

4. BACKGROUND. Service experience indicates that as an airplane ages, increasing care is required in the maintenance process and more frequent inspections or parts replacement of the structure may be needed to maintain the required level of safety. These added inspections should be directed at detecting degradation caused by environmental deterioration and fatigue.

To ensure the continued safe operation of airplanes used in scheduled air carrier service, an "Operational Limit" must be established beyond which operation is not permitted unless specific work is carried out to justify an extension of that limit. At the Operational Limit, the existing maintenance requirements may not be sufficient to allow the airplane to continue to operate in scheduled air carrier "service.

5. DEFINITIONS.

a. Operational Limit. That point in the life of the airplane where additional maintenance action is required to assure the continued airworthiness of the airplane's principal structural elements.

b. Fatigue Evaluation. The evaluation for the prediction of fatigue damage that can be performed by test or analysis based on, but not limited to, Crack Propagation (Fracture Mechanics), S/N (Miner's Rule) or ε/N (Neuber's Rule).

c. Damage tolerance. The attribute of the structure that permits it to retain its required residual strength for a period of usage after the structure has sustained specific levels of fatigue, corrosion, accidental, or discrete source damage.

d. Principal Structural Elements (PSE). An element of structure that contributes significantly to the carrying of flight,

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ground, and pressurization loads and whose integrity is essential in maintaining the overall structural integrity of the airplane.

6. CONTINUED AIRWORTHINESS. The continued airworthiness of the structure of airplanes addressed by this AC can be achieved by the implementation of an Operational Limit for each type of airplane. The maintenance program and the continued airworthiness information currently provided should ensure the continued airworthiness of the airplane for the service period between manufacture and the Operational Limit. When the airplane reaches the Operational Limit, an evaluation of the airplane should occur, any needed parts replacements or modifications should be accomplished, and the airplane should be placed on an inspection and maintenance program that will ensure the continued airworthiness of the airplane for the service period between the Operational Limit and the Extended Operational Limit. The Extended Operational Limit can be re-extended as many times as desired if the condition of the airplane, the additional maintenance, and the information provided to justify the extension are sufficient to ensure the continued airworthiness of the airplane for the extended service period.

a. Development of an Operational Limit. The manufacturer, in conjunction with the operators, is expected to establish an Operational Limit for each airplane type. The Operational Limit should be based on an-evaluation of the crack propagation behavior and/or the fatigue durability of all PSE's. The Operational Limit must be set at a value which provides adequate assurance that neither PSE failure nor Widespread Fatigue Damage will occur before the Operational Limit is reached. Life-limited parts requiring replacement prior to the Operational Limit should be replaced as scheduled. Appendix 1 describes detailed guidelines for setting an Operational Limit.

b. Extension of the Operational Limit. The Operational Limit may be extended for a specified period based on FAA approved actions to ensure continued airworthiness for the specified period. The end of this specified period is the Extended Operational Limit. Appendix 2 describes detailed guidelines to extend an Operational Limit.

To operate to the Extended Operational Limit, additional specific FAA approved actions may be required. The specific actions may include, but are not limited to:

(1) One-time special inspections.

(2) A review of the repairs and alterations.

(3) Modification of the airplane to provide access to accomplish, or to reduce the need for, the inspections of item (1) above or (5) below.

(4) Replacement of components. Life-limited parts due for replacement after the Operational Limit would be replaced on schedule.

(5) Repetitive inspections of specific principal structural elements (PSE's). Inspection intervals for fatigue cracking must be based on the principles of fracture mechanics or crack growth test results.

(6) Any combination of the above.

(7) An effective corrosion prevention and control program.

c. Continued Extension of the Operational Limit. The Extended Operational Limit can be re-extended as many times as desired as long as the condition of the airplane and the information provided to justify the extensions ensure the continued airworthiness of the airplane.

THOMAS E. MC SWEENEY
Director
Aircraft Certification Service

APPENDIX 1 - GUIDELINES TO SET AN OPERATIONAL LIMIT

The guidelines given apply to airplanes of conventional construction using conventional metallic materials. The following is a suggested procedure for this evaluation; however, any alternative procedure that is acceptable to the Federal Aviation Administration (FAA) may be used. The procedure given below is based on the assumption that limited fatigue/fracture data are available for the airplane being evaluated. Portions of this work may not be needed if some data are already available. Guidelines for the extension of Operational Limits are given in appendix 2.

The possibility of Widespread Fatigue Damage must be considered when setting an Operational Limit.

1. DEFINE AIRPLANE USAGE. The average usage is defined by the number and the frequency of typical flight profiles. Since an aging airplane has been in service for a considerable period, such utilization data should be readily available from a survey of typical operators. Each flight profile should be defined in terms of the typical flight parameters: stage length, flight time, take-off weight, fuel load, altitude, climb-cruise-descent speeds, flap settings, etc.

The average usage may be applicable to all airplanes of the same airplane type. However, if individual airplanes of a particular airplane type are used in specialized roles that differ significantly from the average usage or environment for the type, then a separate evaluation for this operation may be needed.

Decisions on Operational Limits should be based on average fleet usage. The Federal Aviation Administration (FAA) may choose to impose specific additional requirements prior to the Operational Limit threshold on those airplanes used in specialized roles.

2. DETERMINE "GLOBAL" LOAD SPECTRA. A "global" spectrum is one that specifies the occurrence frequency of fatigue loads expressed in terms of flight load factor, ground load factor, gust velocity, or landing sink rate. As a minimum, spectra should be developed to specify the loading conditions (a. through f.) listed below. The spectra must be derived to reflect the airplane usage specified by the usage profile. If spectrum data have been recorded for the airplane type under consideration (ideally during operation representing typical service), this data should be used in preference to handbook data.

The reference sources of loads data and analysis methods listed here are provided as information on acceptable methods. Alternative data acceptable to the FAA may be used.

a. Vertical and lateral gust loads.
SOURCES: FAA Report No. AFS-120-73-2
PSD Gust Spectrum Analysis, Part 25, Appendix G
ESDU 69023
DOT/FAA-CT-91/20 General Aviation Aircraft Normal Acceleration Data Analysis and Collection Project
NOTE: ESDU data contain maneuver as well as gust loads. For some airplane types it may be unnecessary to add maneuver loads separately.

b. Maneuver loads.
SOURCES: MIL-A-8866B
FAA Report No. AFS-120-73-2
TM-84660
DOT/FAA-CT-91/20 General Aviation Aircraft Normal Acceleration Data Analysis and Collection Project

c. Taxi loads.
SOURCES: ESDU.75008
FAA Report No. AFS-120-73-2
MIL-A-8866B

d. Landing loads.
SOURCES: MIL-A-8866B
FAA Report No. AFS-120-73-2

e. Pressurization loads (if applicable). In considering fatigue of pressure cabins, full normal operating differential pressure plus external aerodynamic pressure shall be assumed to occur once per flight unless the usage profile specifically defines a Pressurization spectrum,

f. Empennage Loads.
SOURCES: FAA Report No. ACE-100-01 entitled Fatigue evaluation of Empennage, Forward Wing, and Winglets/Tip Fins on Part 23 airplanes.

3. IDENTIFY ALL PRINCIPAL STRUCTURAL ELEMENTS. Typical examples of components that should be considered for PSE designation are:

a. Items with a significantly severe fatigue stress spectrum and/or a low static reserve factor in tension, e.g., wing lower skin panels, stabilizer skin panels, and fuselage pressure shell panels (including pressure bulkheads and domes).

b. Items of primary structure incorporating a design feature which, based on analysis, test, or service experience, could be prone to cracking during the service life of the airplane. Structural discontinuities such as skin panel, spar cap and stringer splices, shell cut-outs, highly loaded fittings (in wing/fuselage joints, stabilizer attachment joints and flap track attachment joints) and flight compartment window posts and door stops or latches (on pressurized airplanes) are examples.

c. Engine mountings, landing gear, and attaching structure.

d. Components exposed to propeller wakes.

All designated PSE's should be listed and subjected to the evaluation detailed below. The determination of the extent of the structure to be covered by each PSE would be influenced by the fatigue evaluation method used to establish an Operational Limit (see paragraph 5 below). For example, if a full scale test of the complete wing is carried out, the entire wing might be declared as one PSE. On the other hand, if analysis is used, multiple PSE's, chosen on the basis of the above guidelines, would be required.

Those PSE's that have existing mandatory replacement times, either identified at certification or by Airworthiness Directive (AD), should not necessarily be used to set the initial Operational Limit. Any parts (e.g., safe-life parts) requiring replacement prior to the Operational Limit should continue to be replaced as scheduled.

4. <u>ESTABLISH "LOCAL" STRESS SPECTRA FOR EACH PSE</u>. Unless stress or local load spectra are available from flight records, stress or local load spectra for each PSE must be determined from the global load spectra by analysis. A means to transform the global load parameters of load factor, gust velocity and landing sink rate into stress or local load at each PSE site must be available. Satisfactory "global load"-to-"stress" (or "global load"-to-"local load") transformations should be possible if internal stresses (or loads) are determined by finite element analysis (or classical methods as applicable) for each of the following unit fatigue cases. These cases should be run for a typical airplane

configuration (weight, c.g. position, etc.) as applicable to each PSE.

a. A 1g level flight case for each significant flight phase in the usage profile (e.g., a case for each flap setting used may be required).

b. A unit vertical gust case (e.g., a 2.0g vertical acceleration) for each significant flight phase in the usage profile.

c. A unit lateral gust case for a nominal lateral gust velocity (e.g., 10 ft./sec.).

d. A 1g on-ground case.

e. A landing case for a sink rate not less than the average sink rate in the fatigue spectrum.

f. A unit cabin pressure case, if the airplane is pressurized.

As an alternative, internal stresses could be obtained from a strain gauge survey under flight conditions that correspond to the above cases. If analysis is used to transform global loads to internal stresses, then some strain gauging may be needed to validate the analysis methods used.

For wing components, in absence of better data, the load-to-stress transformation using internal stresses determined for the above fatigue cases may be accomplished by assuming a linear relationship (lg stress versus stress/g) between stress and vertical load factor, stress and lateral gust velocity, and stress and landing sink rate.

In the generation of the local stress spectra, ground-air-ground cycle loading must be accounted for where significant.

5. <u>DETERMINE LIFE FOR EACH PSE</u>. Fatigue life for each PSE must be determined once a stress spectrum is available. Fatigue life may be determined by one of the methods itemized below:

a. <u>Fatigue Test and/or Analysis</u>. When using fatigue test and/or analysis to establish fatigue life for a PSE, the procedure outlined by the flow chart in Figure 1 should be used (see page 7, Appendix 1). In addition, for PSE's associated with Single Load Path Structure, care should be exercised when considering their structural performance - particularly PSE's made of materials with low fracture toughness. These Single Load Path PSE's should be reviewed to consider their structural integrity as a result of accidental, environmental, and fatigue damage.

(1) Fatigue Tests.

(i) Full Scale Fatigue Test. Results from a full scale fatigue test of a complete airframe or a major component (e.g., a complete wing or fuselage) using a representative fatigue spectrum such as that determined with the above guidelines may be utilized to establish a fatigue life. An appropriate spectrum simplification may be acceptable to expedite the test. Fatigue life would be taken as time to detectable cracking or test termination if no cracking occurs. Use of a full scale fatigue test may preclude the need for local stress spectra.

(ii) Fatigue Test of Representative Specimens. Results from a detail fatigue test of the local structure covered by a PSE being evaluated (e.g., a wing spar joint) using a representative fatigue spectrum such as that determined with the above guidelines, may be utilized to establish a fatigue life. An appropriate spectrum simplification may be acceptable to expedite the test. Fatigue life would be taken as time to detectable cracking or test termination if no cracking occurs.

(2) Fatigue Analysis. When performing fatigue analysis, the Crack Propagation Analysis method described below (paragraph 5.a.(2)(i) of Appendix 1) is preferred.

(i) Crack Propagation Analysis. Fatigue life may be calculated by crack propagation (fracture mechanics) analysis assuming the existence of a small crack to represent a manufacturing flaw located at the most critical site in the structure covered by the PSE being evaluated. The analysis should be carried out using a representative fatigue spectrum such as that determined using the above guidelines. Analysis should commence with a crack of appropriate size and location. Fatigue life is the time taken for this crack to propagate to the largest size at which the structure can still sustain required residual loads (usually limit loads).

Linear elastic (unretarded) crack propagation analysis may be used, because this method is conservative for most transport airplane fatigue spectra. If crack growth retardation analysis is used, appropriate test validation must be provided. Crack propagation (da/dN) data and fracture toughness data may be taken from acceptable references (such as MCIC-HB-01R, MIL-HDBK-5, or ESDU sheets), or the data may be generated by appropriate coupon testing. Crack geometry factors for most configurations are available (or can be derived by superposition or compounding) from the following references:

(A) D. P. Rooke & D. J. Cartwright, "Stress Intensity Factors."

(B) H. Tada, P. Paris, G. Irwin, "The Stress Analysis of Cracks Handbook."

(C) Murakami Y., "Stress Intensity Factors Handbook," Vols. 1 & 2.

(ii) Analysis Using Constant Amplitude S-N Data. In some cases, fatigue life may be determined using constant amplitude S-N data and linear cumulative damage calculation (Miner's Rule). This method should be restricted to structure made of fracture tough materials where the S-N data has been obtained from testing of structure that is of the same type as the PSE being evaluated. Handbook S-N data obtained from typical coupon type test specimens would not normally be acceptable for such analysis.

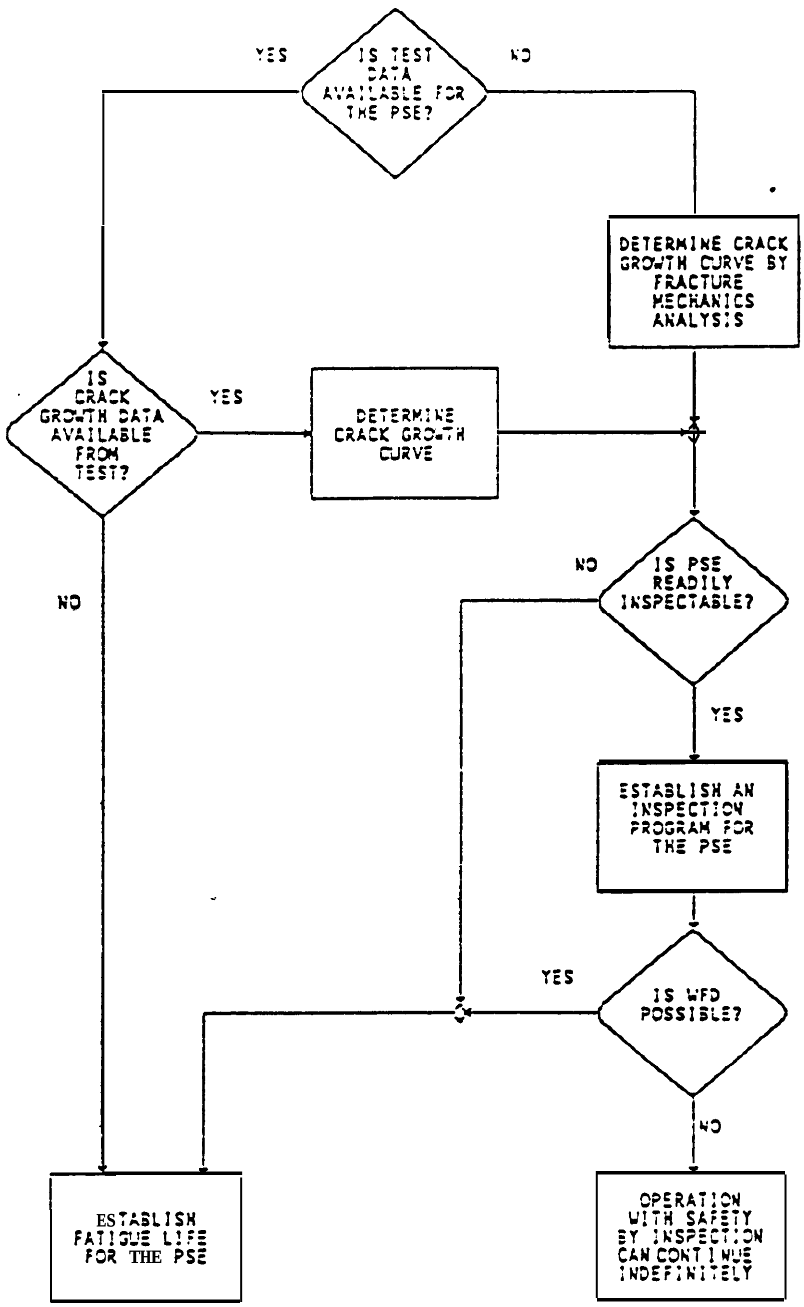

Figure 1 - PSE LIFE/INSPECTION DETERMINATION BY ANALYSIS AND TEST

b. Comparison with Similar Structure. Fatigue life may be derived by demonstrating a quantitative relationship with similar structure for which a fatigue life has already been established by test. That is, the structural and load spectrum differences between the PSE being evaluated and a similar component for which a fatigue life is already available may be sufficiently small to justify life adjustment by analysis to account for those differences. This adjustment could be made by comparative fatigue damage calculation (a procedure sometimes termed the "Relative Miner Rule"), or by comparative crack propagation (fracture mechanics) analysis.

c. Use of a Fleet Based Limit. If life determination by any of the above methods is not practical, it may be acceptable to establish a life from the service time accumulated by individual members of the fleet. An evaluation of the accumulated service times using an acceptable statistical analysis method would have to be carried out to obtain fleet life for a confidence and probability level agreed to by the FAA. Life determined in this manner would have to be divided by the K1 factor specified in paragraph 6 below to obtain the factored life. If an Operational Limit is to be based on fleet accumulated time, it is highly desirable that high time airplanes be inspected to establish their cracking, corrosion and repair status. Also, fleet utilization records should be examined to confirm that past fleet usage is sufficiently representative of present and intended future usage. The extent of any inspections carried out and the results of the fleet utilization review are factors that should be considered in the choice of K1 magnitude. It should be noted that life based on fleet accumulated time would be significantly lower than the time accumulated by the fleet leader.

6. DETERMINE THE FACTORED LIFE OF EACH PSE. A factored life should now be determined for each PSE from:

$$\text{FACTORED LIFE} = \frac{\text{FATIGUE LIFE}}{\text{K1}}$$

where,

FATIGUE LIFE equals the PSE Fatigue Life determined by any of the methods 5a to 5c of Appendix 1, and K1 represents a reduction factor that accounts for the variability of the method chosen and the quality of the available data.

a. K1 VALUES. A range of K1 values for each method are given below:

K1 = 2.0 to 5.0 if life established using method 5a(1)(i)
= 3.0 to 7.0 if life established using method 5a(1)(ii)
= 2.0 to 4.0 if life established using method 5a(2)(i)
= 6.0 to 10.0 if life established using method 5a(2)(ii)
= 2.0 to 5.0 if life established using method 5b
= 1.0 to 1.5 if life established using method 5c

b. DISCUSSION OF K1 VALUES. The range of K1 values provided above are given for guidance purposes only and are subject to acceptance by the FAA for the structure being evaluated. Any test based lives previously approved by the FAA and the factors on which they were based, i.e., life obtained using above method 5a(1) of this Appendix, would qualify for acceptance without change, provided that the spectrum loading on which the test based lives are based is still relevant.

The following is a discussion of the above K1 values and the industry precedents and practices.

(1) Full Scale Fatigue Tests, Method 5a(1) (i): Factors between 2.0 and 5.0 have been accepted in military and civilian certifications. The lower bound, 2.0, has been used as a service life indicator for damage tolerant or multi-load path structure. A full scale fatigue test to two times the proposed limit may be assumed to account for the possibility of widespread fatigue damage.

A factor of 3.0 has been accepted in FAA certification of safe life structure such as landing gears and multi-element structure (i.e., many replicates of similar design details in the same test article) such as pressure cabins. 'The upper bound of 5.0 has been applied (especially in Europe) to increase confidence levels in cases where the inservice load or stress spectra have not been based on measured data. FAA Engineering Report, AFS 120-73-2, "Fatigue Evaluation of Wing and Associated Structure on Small Airplanes," recommends between 3.0 and 5.0, with the lower number applied when supported by knowledge of critical crack locations and inspectable crack growth rates.

(2) Representative Specimen Tests, Method 5a (1) (ii): Factors between 5.0 and 7.0 have been used in certification of fatigue lives based on specimen testing. Typically 6.0 or 7.0 has been used based on specimen test results, and as low as 5.0 when test results were backed up with flight measured strain data. Lower factors could be applied when specimen test results include

applicable crack growth results. FAA Engineering Report, AFS 120-73-2, "Fatigue Evaluation of Wing and Associated Structure on Small Airplanes," recommends between 5.0 and 7.0.

Certifications of single load path structure by other airworthiness authorities have used factors of: 3.33 for material scatter; 1.0-1.5 for fleet usage scatter; and 1.0-2.0 for test quality scatter. In the case of multiple load path structure the 3.33 factor may be reduced to a factor of 2.0. These factors are then multiplied together to give an overall factor (K1). Thus for representative test specimens a factor between 3.0 and 5.0 is likely to result.

(3) Crack Propagation Analysis, Method 5.a.(2)(i): A K1 value of 2.0 for multiple load path structure, and 3.0 for single load path structure, has usually been applied in defining a replacement life or inspection threshold based on fracture mechanics calculations or crack growth test results that take into account the possibility of manufacturing or maintenance induced flaws in critical locations.

(4) Analysis Using Constant Amplitude S-N Data, Method 5.a.(2)(ii): For fatigue analysis not supported by test results or flight measured data, higher K1 values are required. FAA Engineering Report, AFS 120-73-2, "Fatigue Evaluation of Wing and Associated Structure on Small Airplanes," recommends 8.0 for analysis alone and possibly 7.0 when analysis is supported by flight measured data and/or comparison to successful similar designs. Following the philosophy of 6.b.(2), the applicable factor for other Regulatory Authorities has been between 6.0 and 10.0.

(5) Comparison With Similar Structure, Method 5b: Where design details, stress levels, load spectra, etc. are similar between those of a new design and a proven successful design, then a proposal may be made in which the K1 factor is also based on the value applied in the successful design.

(6) Fleet Based Limit, Method 5c: Where fleet history data are available, a K1 factor may be applied to the statistically derived number of hours that represents a low probability of the presence of fatigue cracks.

7. WIDESPREAD FATIGUE DAMAGE. Widespread Fatigue Damage (WFD) in a structure is characterized by the simultaneous presence of multi-site cracks that are of sufficient size and density to degrade strength of the structure below its damage tolerance requirement. Such cracks are initially independent and usually non-uniform, but

may interact to increase in size. This could result in a significant increase in crack propagation rate and/or a reduction in residual strength capability. Because these cracks are relatively small and therefore difficult to detect, there is the risk of sudden coalescence that could possibly lead to total structural failure without adequate prior warning.

Widespread Fatigue Damage may occur either as Multiple Site Damage (MSD) or as Multiple Element Damage (MED)

a. Multiple Site Damage: Multiple Site Damage is characterized by the simultaneous presence of fatigue cracks in the same structural element. Simultaneous cracking at multiple locations can occur because a particular feature is replicated many times, with equal or very near equal stress exposure at all locations (a fuselage longitudinal skin joint is an example of such structure).

b. Multiple Element Damage: Multiple Element Damage is characterized by the simultaneous presence of fatigue cracks in similar adjacent structural elements in a multi-load path component (a control surface hinge consisting of side-by-side duplicated members is an example of such structure).

Most airplanes contain at least some structure of a design, which could lead to WFD. For such structure, the possibility of WFD must be considered in the *determination of the Operational Limit. In many instances this can be achieved by an appropriate choice of K1 factor (see paragraph 6).

Further guidelines for the evaluation of WFD are given in the following references:

a. "A Report of the Airworthiness Assurance Working Group Industry Committee on Widespread Fatigue Damage," Final Report dated July 1993.

b. "Damage Tolerance, Facts and Fiction", Ulf Goransen, 17th ICAF, June 1993.

c. "Widespread Fatigue Damage Monitoring-Issues and Concerns", Tom Swift, Proceedings from 5th International Conference on Structural Airworthiness of New and Aging Aircraft. June 16-18, 1993.

8. DETERMINATION OF THE OPERATIONAL LIMIT. The Operational Limit for the airplane is determined by the lowest factored life established in Paragraph 6 Appendix 1.

OPERATIONAL LIMIT = MINIMUM FACTORED LIFE

However, the operational limit should never be set higher than the time at which WFD can be expected to occur.

If a PSE is kept in service using safety by inspection (see appendix 2) and the PSE is prone to WFD, the Operational Limit for that PSE is determined by the development of WFD.

APPENDIX 2 - GUIDELINES TO EXTEND AN OPERATIONAL LIMIT

The guidelines given apply to airplanes of conventional construction using conventional metallic materials. The following is a suggested procedure for this evaluation; however, any alternative procedure that is acceptable to the Federal Aviation Administration (FAA) may be used. The procedure given below is based on the assumption that limited fatigue/fracture data are available for the airplane being evaluated. Portions of this work may not be needed if some data are already available.

Using these methods, the Operational Limit can be extended to the time when the life of the next critical PSE is reached. It may also be extended to the highest time of the lives of a group of PSE's when the inspection, modification, and/or replacement actions due between the Operational Limit and the Extended Operational Limit are accomplished.

1. METHODS FOR EXTENDING THE OPERATIONAL LIMIT. The Operational Limit can be extended by any of the following methods:

When an airplane or component (wing, fuselage, stabilizer, etc.) operational limit is extended by treatment of PSE's by any of the methods described in sections la, lb, or 1c of Appendix 2, the potential for widespread fatigue damage in other parts of the affected components must be evaluated in accordance with appendix 1, paragraph 7; except, under paragraph lb when the affected components have been tested to the equivalent of two times the extended operational limit.

a. PSE Replacement or Modification. Since the Operational Limit is determined by the PSE with the shortest factored life, the limit can be extended by replacement of this PSE, or by a modification that extends its fatigue life. The new Operational Limit would then be set by the PSE with the next lowest factored life or the factored life of the modified/replaced PSE, whichever is lower.

b. Further Testing or Analysis. Further testing and/or analysis in accordance with the guidelines given in paragraph 5a to 5e of appendix 1 may be undertaken if the potential exists to justify longer lives than those determined by the first evaluation. For example, a fatigue test may have been terminated for economic reasons before the development of Widespread Fatigue Damage and/or any significant fatigue failures had occurred. In that case, an extended test could justify a longer fatigue life.

c. Re-Evaluation of Data Used to Establish the Initial Operational Limit. The Operational Limit may have been established as a result of initial assumptions. A re-examination of these assumptions may lead to an Extended Operational Limit.

For example, the aircraft may have had an Operational Limit set on the basis of an assumed usage. Over time, the actual usage may be determined. A re-evaluation of the original data using the actual usage may result an Extended Operational Limit.

d. Continued Operation with Safety by Inspection. The Operational Limit can be extended beyond the currently declared value if it is shown that safe operation is possible by implementation of an appropriate inspection program. The inspection program should ensure that if any cracks occur, they will be detected by mandatory inspections before the required residual strength is lost. Extension of the Operational Limit by this method is feasible only for structure which is inspectable for cracking. The detectable crack size must be substantiated for each Principal Structural Element (PSE) to be evaluated by this method. A crack propagation analysis (or test) must be carried out to determine the time (flights or flight hours) for a detectable crack to reach the maximum permitted size, i.e., the largest size where the structure can still sustain required residual load, This is the available crack detection time.

If analysis is used, the guidelines in paragraph 5a of Appendix 1 for crack propagation analysis apply, except that the analysis is commenced from a detectable flaw size. For crack propagation analysis in a pressure shell, the crack geometry factors used must account for pressure bulging effects. For multi-load path structure, detectable crack size may include the total failure of one element. The available crack detection time is then the time taken for cracking in the secondary path(s) to reach maximum permitted size.

For crack propagation analysis purposes, it is acceptable to assume that given a primary path failure, cracking in the secondary path(s) continues from a 1/4 circular corner crack of size $a_o+\delta a$, where ao is the typical imperfection flaw size and δa is the amount by which a crack of size ao would propagate with all load paths intact during a period equivalent to the primary path crack propagation.

The maximum permissible crack size, as defined above, can be determined either by residual strength test or by fracture mechanics analysis using representative fracture toughness data.

Inspection interval for each PSE then becomes:

$$\text{REPEAT INSPECTION INTERVAL} = \frac{\text{AVAILABLE CRACK DETECTION TIME}}{K2}$$

where, K2 = 3.0 for single-load path structure
2.0 for multi-load path structure

Any item cleared by the above procedure for continued operation through safety by inspection may continue in service indefinitely, provided that the item is not prone to WFD in accordance with Appendix 1, paragraph 7. Such items no longer need to be considered to determine an Operational Limit; the Operational Limit would be determined by the lowest life of the remaining items not cleared for continued operation through safety by inspection. The Operational Limit can therefore be extended progressively by revalidating more of the lowest life components using the safety by inspection method, provided that the components are inspectable and that assessments made prior to extension validate that WFD of any such component is not a concern during the Operational Limit extension interval.

2. INSPECTION PROCEDURE FOR SAFETY BY INSPECTION. For any structure evaluated by the procedure specified in paragraph 1c, Appendix 2, an inspection procedure that can reliably detect cracks of the assumed detectable size must be developed and documented. The following inspection procedures are commonly used:

a. Visual.

b. Eddy current (usually paint removal is not required).

c. Visual with fluorescent dye penetrant (paint removal is usually required).

d. Ultrasonic (for non-accessible structure where crack can be approached from the side).

e. Radiographic - this is not a preferred method. The probability of detection is dependent on crack opening (more than crack length), on beam orientation, and on operator judgment.

f. Magnetic Particle

Detectable crack size depends on factors such as:

(i) Inspection technique.

(ii) Structure geometry, accessibility, and the amount of structure to be inspected.

(iii) Inspection specificity (i.e., is the inspection directed at a specific point?).

(iv) Damage location indicators (i.e., fuel leaks, pressure loss, and working fasteners).

3. OPERATIONAL LIMIT EXTENSION CRITERIA. A document should be prepared that defines the requirements for the operation of the airplane to its Extended Operational Limit. The document should be in a form that can be added to the existing maintenance program of the airplane, or it can be in a "stand alone" document to supplement the existing maintenance program.

4. REVISE MAINTENANCE PROGRAM TO INCLUDE INSPECTIONS. The inspections identified for any PSE evaluated in accordance with paragraph lc of this appendix shall be incorporated into the operator's approved maintenance program. Any extensions of these inspection intervals must be approved by the responsible FAA Aircraft Certification Office (ACO).

ATTACHMENT C

Memo to William C. Keil
Regional Airline Association
Chairman, SAA W G
Voice: 202 857-1170
Fax: 202 429-5113

From J W Mar
Chairman, TOGAA
Voice / fax: 408 373-3449

4 June 1994

1. The expectations that TOGAA had at the conclusion of our 13, 14 January, 1994 meeting have not been fulfilled in the final draft of AC 91-XX (dated Apr 11 1994) that you sent to us. We cannot endorse the Apr 11 draft.

2. A key element has been removed from section 5. The Apr 11 draft of the AC now permits an operational limit to be established for single load path structures using Minor's Rule without comparative crack growth evaluation for equivalent reliability. TOGAA has recommended that thresholds for inspections (operational limits) be based on the "Policies for Fatigue Inspection Thresholds" contained in the revised version of AC 25.571 that has gained Industry approval.

3. Our recollection is that the understanding reached on 14 January was changed as the result of your final meeting. As has been shown by this experience it is very difficult to write an advisory circular with two groups.

4. The SAAWG as a part of ARAC is an advisory committee to the FAA. TOGAA is an oversight group. The FAA has the final responsibility of evaluating the AC and has the prerogative of making changes.

5. My suggestion at this point in time is to let the FAA determine what they need. However, we are willing to continue discussions if you so desire.