U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: Fatigue Management Programs for In-Service Issues

Date: 10/1/12
Initiated by: ACE-100

AC No: 91-82A
Change: 1

1. PURPOSE. This change revises existing paragraph numbering throughout the entire document, excluding attachments. The change number and the date of the changed material are shown at the top of each changed page. Vertical bars in the margin indicate the changed material. Pages having no changes retain the same heading information.

2. PRINCIPAL CHANGES. Paragraph 3 has become bullet six in paragraph 2b. All remaining main paragraph numbers have changed accordingly. No content changes have been made. A vertical change bar appears next to the principle change, paragraph 2b, bullet six. Additionally, a spelling correction was made on the x-axis title in figure 4-2 in appendix 4.

PAGE CONTROL CHART

Remove Pages	Dated	Insert Pages	Dated
2-3	8/23/11	2-3	10/1/12
5-7	8/23/11	5-7	10/1/12
10-11	8/23/11	10-11	10/1/12
24	8/23/11	24	10/1/12
26	8/23/11	26	10/1/12
28	8/23/11	28	10/1/12
A4-3	8/23/11	A4-3	10/1/12

s/

Earl Lawrence
Manager, Small Airplane Directorate
Aircraft Certification Service

- Airplanes certificated in the primary and restricted categories.

b. The following may use this AC to develop FMPs:

- DAHs,
- Applicants for STCs,
- Applicants for AMOC to ADs,
- Applicants for PMA,
- FAA aircraft certification engineers, and
- FAA Designated Engineering Representatives (DER) or delegated organizations.

3. Cancellation. This AC cancels AC 91-82, Fatigue Management Programs for Airplanes with Demonstrated Risk of Catastrophic Failure Due to Fatigue, dated April 29, 2008.

4. Related Regulations. Refer to the following Title 14 of the Code of Federal Regulations (14 CFR) sections, as applicable.

a. Design approval holder responsibilities for reporting of failures, malfunctions and defects included in part 21, § 21.3.

b. Certification procedures for instructions for continued airworthiness (ICA) and airworthiness limitations included in part 21, § 21.50.

c. Certification procedures for changes to type designs included in part 21, § 21.93.

d. Requirements for Supplemental Type Certificates (STC) included in part 21, § 21.113.

e. Small airplane requirements for strength and deformation included in part 23, § 23.305.

f. Small airplane requirements for fatigue, fail-safe, and damage-tolerance evaluations included in part 23, §§ 23.571, 23.572, 23.573, 23.574, and 23.627.

g. Small airplane requirements for inspections and ICAs included in part 23, §§ 23.575, 23.611, and 23.1529.

h. Transport category airplane requirements for strength and deformation included in part 25, § 25.305.

i. Transport category airplane requirements for fatigue and damage-tolerance evaluations included in part 25, § 25.571.

j. Transport category airplane requirements for inspections and ICAs included in part 25, §§ 25.611 and 25.1529.

k. AD requirements included in part 39.

5. Definitions. The following definitions apply for this AC:

a. Accident. An occurrence associated with the operation of an aircraft, which takes place between the time any person boards the aircraft with the intention of flight and all such persons have disembarked, and in which any person suffers death or serious injury, or in which the aircraft receives substantial damage.

b. Applicant. An applicant is any interested party who is developing a fatigue management program.

c. Damage-Tolerance Based Inspection. An inspection based on consideration of the crack growth and residual strength characteristics of the structure, the physical access to the structure, and the inspection method reliability. The inspection should provide a high probability of detecting fatigue damage before the residual strength degrades below a specified value.

d. Demonstrated Risk.

(1) An airplane type design has a "demonstrated risk" when an unsafe condition due to fatigue exists in that type design and the condition is likely to exist or develop in other airplanes of the same or similar type design. The FAA will determine the necessary action to address a fatigue cracking scenario using the corrective action review board process in accordance with FAA Order 8110.107.

(2) Situations that could precipitate a risk analysis may include:

- An airplane has experienced a catastrophic failure due to fatigue and the same scenario is likely to occur on other airplanes in the fleet,
- Airplanes of the type design have a service history that indicates a significant likelihood of catastrophic failure due to fatigue in the fleet,
- Fatigue testing of the type design indicates a significant likelihood of catastrophic failure due to fatigue in the fleet, or
- The type design has a structural area sufficiently similar to another type design's structural area determined to present a demonstrated risk.

e. Design Approval Holder (DAH). For the purposes of this AC, a holder of a type certificate (TC), STC, or Part Manufacturing Approval (PMA) issued under part 21.

f. Fatigue Critical Structure. For purposes of this AC, structure that is susceptible to fatigue cracking that could contribute to catastrophic failure of an airplane if there is no intervention. This would typically include all structure critical to carrying flight, ground or pressurization loads that are subjected to tension dominated repeated loads during operation.

6. Related Publications (current editions).

a. ACs**.**

(1) AC 21-40A, Application Guide for Obtaining a Supplemental Type Certificate, dated September 27, 2007.

(2) AC 23-13A, Fatigue, Fail-Safe, and Damage-Tolerance Evaluation of Metallic Structure for Normal, Utility, Acrobatic, and Commuter Category Airplanes, dated September 29, 2005.

(3) AC 25.571-1D, Damage Tolerance and Fatigue Evaluation of Structure, dated January 13, 2011.

(4) AC 43-4A, Corrosion Control for Aircraft, dated July 25, 1991.

(5) AC 43.13-1B, Acceptable Methods, Techniques, and Practices – Aircraft Inspection and Repair, dated September 27, 2001.

(6) AC 91-56B, Continuing Structural Integrity Program for Airplanes, dated March 7, 2008.

b. Orders.

(1) FAA Order 8040.1C, Airworthiness Directives, dated October 3, 2007.

(2) FAA Order FAA-IR-M 8040.1C, Airworthiness Directives Manual, dated May 17, 2010.

(3) FAA Order 8110.4C CHG 3, Type Certification, dated March 15, 2010.

(4) FAA Order 8110.54A, Instructions for Continued Airworthiness: Responsibilities, Requirements, and Contents, dated October 23, 2010.

(5) FAA Order 8110.103A, Alternative Methods of Compliance (AMOC), dated September 28, 2010.

(6) FAA Order 8110.107, Monitor Safety/Analyze Data, dated March 12, 2010.

(7) FAA Order 8900.1, Flight Standards Information Management System (FSIMS), dated September 13, 2007.

c. Others.

(1) Best Practices Guide for Maintaining Aging General Aviation Airplanes, Appendix 1, Aging Airplane Inspection & Maintenance Baseline Checklist for Airplanes Without a Type Specific Checklist, dated September 2003. An electronic version is available at http://www.faa.gov/aircraft/air_cert/design_approvals/small_airplanes/cos/aging_aircraft/media/aging_aircraft_best_practices.pdf.

(2) Commercial Airplane Certification Process Study, An Evaluation of Selected Aircraft Certification, Operations, and Maintenance Processes, FAA, March 2002.

(3) DOT/FAA/CT-93/69.1 and DOT/FAA/CT-93/69.2, Damage Tolerance Assessment Handbook, Volumes 1 and 2, dated October 1993.

(4) FAA and Industry Guide to Product Certification, Second Edition, dated September 2004.

(5) General Aviation Manufacturers Association's Specification No. 2, Maintenance Manual.

(6) Nondestructive Evaluation (NDE) Capabilities Data Book, W.D. Rummel and G.A. Matzkanin, Nondestructive Testing Information Analysis Center (NTIAC), Texas Research Institute, Austin, Texas.

7. Background.

a. In the early 1980s, because of concerns about the continued airworthiness of older airplanes certified to the Civil Air Regulation (CAR) 4b fail-safe requirements, the FAA began issuing ADs mandating damage-tolerance based structural inspection programs. The intent of the programs mandated by these ADs was to prevent unacceptable degradation of the structural integrity of the affected airplanes to assure long-term continued operational safety of the fleet. These programs proactively addressed potential fatigue that could develop into a demonstrated risk. Per the definition in this AC, these programs are considered FMPs.

b. There have been airframe fatigue-related accidents and incidents that have required certain follow-on actions to maintain the continued operational safety of the fleet. Except for the requirement to report failures, malfunctions, and defects in § 21.3, no specific regulation or guidance exists to assist an applicant on what actions to take following a catastrophic failure due to fatigue or an in-service finding of fatigue cracking. Consequently, the FAA has worked on a case-by-case basis with applicants, owners, and operators to determine the actions needed to maintain the continued operational safety of these airplanes.

c. Reactively, to address a known unsafe condition that is likely to occur on other airplanes of the same type design, the FAA has mandated actions that deal with the specific unsafe condition. These actions typically include inspections, repair, or replacement of specific fatigue critical structural parts. However, in-service experience and fatigue test data have shown that actions to address one unsafe condition and extend the operation of a model fleet allowed a second unsafe condition to develop. Therefore, occurrence of fatigue in one critical part may be a precursor to fatigue in other critical structure that should be addressed proactively.

d. Based on the above, the FAA developed this guidance to assist an applicant on what actions to take following a catastrophic failure due to fatigue or an in-service finding of fatigue cracking that poses a demonstrated risk. The FAA determined that any proposed inspection of the structural elements directly related to the unsafe condition should be based on damage tolerance principles. The FAA also determined that, at a minimum, service history based inspections should be established for other areas considered fatigue critical.

8. Applicability of Certification Requirements to Address a Demonstrated Risk. The guidance in this AC describes how applicants may apply concepts contained in the metallic structure fatigue requirements in 14 CFR to address a demonstrated risk. The requirements include several approaches[1] for preventing catastrophic failure due to fatigue in new type designs. These approaches may also be used to address a demonstrated risk. To apply any of these approaches successfully, applicants should have demonstrated knowledge, abilities, skills, and understand:

- The intent of the 14 CFR fatigue and damage tolerance requirements,
- The underlying philosophy of the fatigue prevention approaches, and
- How to apply these approaches to address a specific demonstrated risk.

For airplanes that have experienced a demonstrated risk, the FAA considers compliance to the latest fatigue requirements will materially contribute to the product level of safety. Therefore, normal, utility, acrobatic, or primary category airplanes with a type certification basis that does not include fatigue requirements should comply with the latest fatigue requirements amendment for any replacement or modified structure. Airplanes with a type certification basis that includes fatigue requirements must comply with those fatigue requirements for any replacement or modified structure. The applicant must calibrate a safe-life or inspection program to the service history that resulted in the demonstrated risk. For a fail-safe design, an applicant must address the challenges associated with achieving a fail-safe design, as described in AC 23-13A, Chapter 3. For commuter and transport category airplanes whose certification basis includes damage-tolerance, any replacement or modified structure must comply with the applicable damage-tolerance requirements. For restricted category airplanes, any replacement or modified structure must comply with the airplane category used for type certification under § 21.25.

a. Safe-Life. For airplanes certificated using the safe-life approach, the safe-life of a structure is the number of events, such as flights, landings, or flight hours time in service during which there is a low probability the strength will degrade below its design ultimate value due to fatigue. The safe-life is a point in the airplane's operational life when the operator must replace, modify, or take the structure out of service to prevent it from developing fatigue cracks that can degrade the strength below its design ultimate value.

(1) An applicant can use the safe-life approach to address a demonstrated risk by establishing a point in the operational life of the airplane when the operator must replace,

[1] For new type designs constructed with metallic structure seeking certification in the normal, utility, and acrobatic categories, 14 CFR part 23 allows the applicant to choose between the safe-life, damage-tolerance, and fail-safe design approaches. For new type designs in the commuter category or designs using composite materials, part 23 requires the applicant to use damage-tolerance, unless the applicant shows that damage-tolerance is impractical. For transport category airplanes, 14 CFR part 25 requires the use of damage-tolerance, unless the applicant shows that damage-tolerance is impractical.

(5) For commuter and transport category airplanes whose certification basis includes damage-tolerance, any fail-safe modification of the structure must comply with the applicable damage-tolerance requirements.

9. Overview of Fatigue Management System. In cases where accidents or incidents involve fatigue cracking, the FAA will act to determine if the type design (or supplemental type design) has a demonstrated risk. If the FAA determines a demonstrated risk exists, the FAA may require maintenance actions to address the risk. An FMP, as described in this AC, is one method applicants may use to address the demonstrated risk. This AC also provides proactive means to address the broader risk, which are inspections for cracks in other fatigue critical structure of airplanes of the same type design.

a. The FAA may require an FMP to meet the risk management guidelines established by the accountable directorate under the FAA Safety Management System (SMS). Appendix 1 contains more information regarding SMS.

b. Figure 1 provides an overview of a fatigue management system. It depicts steps the FAA and applicants should follow when they suspect a risk of catastrophic failure due to fatigue. Appendix 2 describes in detail the steps the FAA takes to determine if a demonstrated risk exists. Paragraphs 10, 11, and 12 describe the actions needed once the FAA has determined a demonstrated risk exists.

(1) In some instances, the FAA will mandate initial, short-term actions to provide short-term mitigation of the demonstrated risk and allow the fleet to return to service. These short-term actions often include operating limitations or immediate and short-interval inspections. The FAA often mandates these short-term actions with an emergency AD or immediately adopted rule (IAR) AD.

(2) In some instances, applicants may develop other interim actions and gain FAA approval after the FAA has issued an AD. 14 CFR 39.19 and 39.21 permit an AMOC to an AD. In accordance with those regulations, if the interim actions adequately mitigate the demonstrated risk, the FAA may approve the interim actions as an AMOC to the AD. The aircraft certification office (ACO) responsible for the AD will approve the AMOC. The AMOC approval will stipulate all the specific requirements and limitations of the interim action. When properly coordinated between the ACO, interim action applicant, and appropriate flight standards district office (FSDO), the combination of the AMOC approval and performance of the actions stated in the approval suffices as compliance with the AD portion the AMOC addresses. The Alternative Method of Compliance Order, 8110.103C, provides detailed guidance regarding use and approval of AMOCs.

(3) Appendix 3 contains examples of suitable AD language if the FAA decides to mandate an FMP with an AD.

c. Figure 1 also outlines the basic actions an applicant should take to develop an FMP to address a demonstrated risk. The purpose of an FMP is to prevent future catastrophic failures due to fatigue and to maintain the type design strength and stiffness of the airframe throughout the operational life of the airplane. As shown in Figure 1, there are two main components to an FMP to address a demonstrated risk developed in accordance with this AC.

(1) Damage-Tolerance Based Inspections or Replacement/Modification of Structural Elements Directly Related to the Unsafe Condition. Applicants should base this component of the FMP on a comprehensive damage-tolerance or fatigue evaluation, as applicable, and as explained in paragraph 10. The applicant may limit the scope of the detailed evaluation to the structural elements directly related to the unsafe condition.

(2) Inspections of Other Fatigue Critical Structure in the Airplane. This component of an FMP provides for proactive inspections of other fatigue critical structure. These inspections address the broader risk affecting the type design. The inspection requirements may be service history based or damage-tolerance based depending on whether or not an FMP already exists and what it contains.

d. Paragraph 10 describes the FMP development process. Applicants should document the FMP maintenance actions in the ICA.

e. Paragraph 11 explains the approval of an FMP and the coordination needed for those approvals.

f. Paragraph 12 discusses FMP implementation. The operator accomplishes implementation of the FMP by following the instructions prescribed in the ICA.

10. Developing an FMP. This paragraph describes the development of an FMP. The flowchart in Figure 2 outlines the decisions and actions an applicant should follow when developing an FMP.

a. Components of an FMP. Any FMP proposed by an applicant to address a demonstrated risk should include each of the following components:

(1) Damage-Tolerance Based Inspections or Replacement/Modification of the Structural Elements Directly Related to the Unsafe Condition.

(a) An applicant may limit the scope of this component of an FMP to the structural elements directly related to the unsafe condition.

(b) An applicant may propose an inspection or a part replacement/modification program to address the demonstrated risk. An applicant should base any inspection program on a damage-tolerance evaluation of the affected structure. They should base the time in service for a part replacement/modification (effectively a safe-life) on a fatigue analysis or crack growth analysis. Any part replacement/modification program should demonstrate compliance to the applicable regulations. This includes any subsequent inspection requirements. Any proposed program should incorporate the lessons learned from the service history that led to the FAA's determination of a demonstrated risk.

- Information describing the order and method of removing and replacing parts and any precautions necessary to facilitate inspection;

- Diagram of structural access plates, or how to gain access when access plates do not exist;

- Details for utilizing special inspection techniques, including procedures for these techniques;

- Identification of fatigue critical structure;

- All data on structural fasteners, such as identification and torque values;

- List of required special tools;

- Any necessary shoring, jacking, or other special handling requirements;

- Any subsequent required inspections; and

- Instructions for notifying the FMP holder of positive and negative findings for structural elements directly related to the unsafe condition and positive findings for other fatigue critical structure. Normally, the ICA will include a form specifying all pertinent information about the finding.

(2) Order 8110.54A, Instructions for Continued Airworthiness, Responsibilities, Requirements and Contents, provides guidance about the content of an ICA or its equivalent. The reference in paragraph 6c(5) gives direction in the preparation of maintenance data for the maintenance of general aviation airplanes, including ICA.

(3) Paragraph 11 provides guidance regarding the approval process for documenting the actions associated with an FMP.

11. Coordination and Approvals.

a. When addressing in-service issues, the FAA will approve FMPs that address the demonstrated risk and when an AD mandating an FMP is proposed or issued. The FAA may also approve an FMP as an AMOC to an AD. If approval is required, use the process explained in this paragraph.

b. When following the steps described in this AC, the applicant should communicate and coordinate with the cognizant FAA ACO and FSDO, as appropriate. These offices will coordinate with their respective Directorate and Aircraft Evaluation Group (AEG) offices when necessary. The FAA orders and ACs referenced in this paragraph describe roles and responsibilities depending on the method of approval needed for the specific application.

c. The process an applicant uses to get its FMP approved by the FAA varies according to whether the DAH or another applicant is seeking approval. The FAA encourages applicants to use the appropriately authorized designees to approve, or recommend for approval, the

12. Implementing an FMP. Figure 3 on the next page illustrates the key elements of implementation discussed in detail below.

a. FMP Actions to Address the Demonstrated Risk.

(1) Part Replacement/Modification. Perform part replacement/modification per the instructions included in the ICA.

(2) Damage-Tolerance Based Inspections. Complete inspections per the instructions included in the ICA.

(a) If the inspections detect fatigue cracking, repair or replace the cracked part per FAA-approved repair instructions.

(b) Typically, the FAA includes instructions in the AD for operators to report to the FMP holder both negative and positive crack indications along with the time in service on the aircraft inspected. The AD may also require operators to report positive crack indications and time in service to the FAA. In some cases, the FAA may require reporting of negative crack findings. (Appendix 3 contains examples of crack reporting requirements suitable for an AD.) History of inspection results provides data to measure the success of an inspection program. The FMP holder uses reports of cracks found and their sizes, negative inspection results, and the airplane time in service to assess the inspection program effectiveness. Damage-tolerance based inspections must have a demonstrated high probability of detection so both positive and negative findings are statistically relevant to verify the inspection method is as reliable as assumed. Report results per the instructions contained in the ICA.

(c) If the inspection program finds a crack and verifies another occurrence of the unsafe condition, the FAA will assess the overall risk to the fleet if inspections were to continue. The inspections may continue if the FAA determines the risk level is acceptable. However, the FAA will mandate termination of the inspection program and development of a part replacement/modification program if the FAA determines continued reliance on inspections poses an unacceptable risk level. AC 91-56B contains guidance about the need for mandatory modification programs when reliance on repetitive inspections no longer provides adequate safety. The FAA uses a data-driven SMS approach for determining acceptable risk associated with continued reliance on repetitive inspections. SMS, as it relates to FMPs, is described in Appendix 1.

b. FMP Actions to Address Other Fatigue Critical Structure. Generally, an AD will require operators to accomplish the established inspections for other fatigue critical structure per the instructions specified in the ICA. A crack found by these inspections would require evaluation as a suspected risk of catastrophic failure due to fatigue, as described in Appendix 2. The inspector should report positive inspection findings to the FMP holder and the FAA per the instructions contained in the ICA. Appendix 3 contains examples of suitable AD reporting requirement language for when the FAA uses an AD to mandate an FMP with crack reporting instructions.

13. List of Acronyms.

a. **AC.** Advisory Circular

b. **ACO. Aircraft Certification Office**

c. **AD. Airworthiness Directive**

d. **AEG. Aircraft Evaluation Group**

e. **ALS. Airworthiness Limitations Section**

f. **AMOC. Alternative Method of Compliance**

g. **CAR. Civil Air Regulation**

h. **CFR. Code of Federal Regulations**

i. **CPCP. Corrosion Prevention and Control Program**

j. **DAH. Design Approval Holder**

k. **DER. Designated Engineering Representative**

l. **FAA. Federal Aviation Administration**

m. **FMP. Fatigue Management Program**

n. **FSDO. Flight Standards District Office**

o. **IAR. Immediately Adopted Rule**

p. **ICA. Instructions for Continued Airworthiness**

q. **NASA. National Aeronautics and Space Administration**

r. **NDE. Nondestructive Evaluation**

s. **NTIAC. Nondestructive Testing Information Analysis Center**

t. **NTSB. National Transportation Safety Board**

u. **PMA. Part Manufacturing Approval**

v. **POD. Probability of Detection**

w. **PSCP. Project Specific Certification Plan**

x. **PSP. Partnership for Safety Plan**

FIGURE 4-2. DECREASING REMAINING LIFE IN SECONDARY LOAD PATH WITH TIME FOR MULTIPLE ELEMENT STRUCTURE

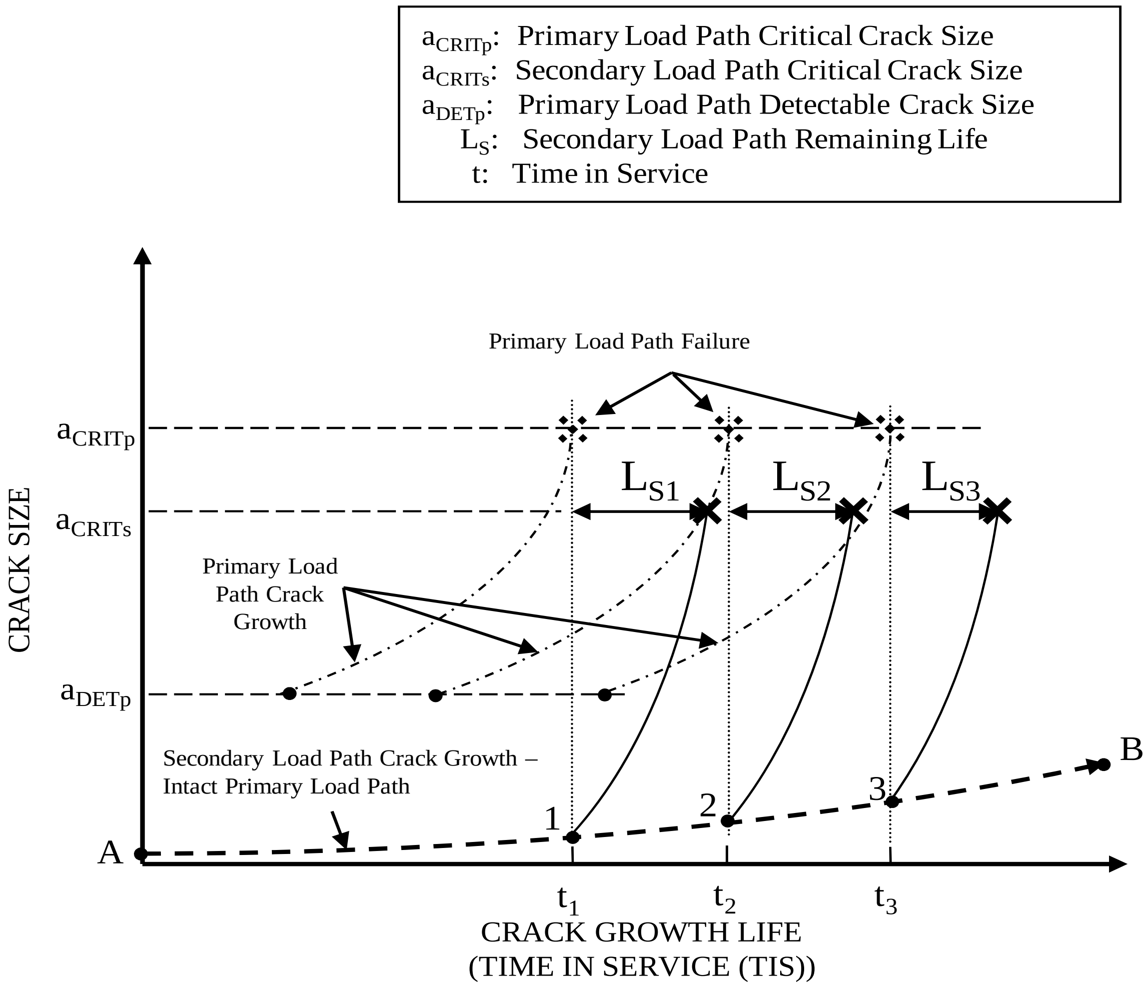

Figure 4-2 illustrates the damage tolerance characteristics of a simple redundant structure consisting of two load paths. The primary load path is the one that is inspected for a crack or complete failure while the secondary load path provides the necessary redundancy. The residual strength of the structure with the primary load path failed and a crack in the secondary load path exceeds the required residual strength until the crack in the secondary load path grows to critical size (a_{CRITs}). Three different crack growth scenarios are shown for a detectable size crack in the primary load path. Each scenario corresponds to the crack in the primary load path becoming detectable at a different point in time and then growing to critical size (a_{CRITp}) and causing complete failure of the primary load path at different points in time (i.e., t_1, t_2 and t_3). At the time of primary load path failure, loading on the secondary load path will increase due to load redistribution and crack growth will accelerate (e.g., subsequent growth from point 1, 2, or 3 depending on if the failure occurs at time t_1, t_2 or t_3). Note that the amount of remaining life in the secondary load path (L_S) has an inverse relationship to the time at which primary load path failure occurs. For example, L_{S3} is less than L_{S2}, which is less than L_{S1} because the longer crack