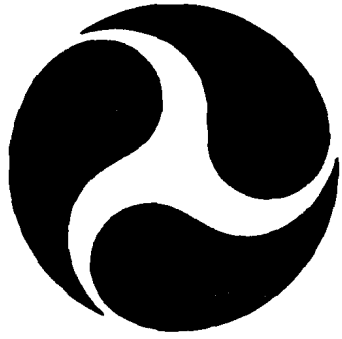
DOT/FAA/CT-88/32

Program Plan

National Aging Aircraft Research Program



August 1989

DOT/FAA
CT-88/32

U.S. Department of Transportation
Federal Aviation Administration
Technical Center
Atlantic City International Airport, New Jersey 08405

National aging aircraft research program : program plan, ACT Library, 00020965

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT/FAA/CT-88/32		

4. Title and Subtitle	5. Report Date
PROGRAM PLAN - NATIONAL AGING AIRCRAFT RESEARCH PLAN	August 1989
	6. Performing Organization Code ACD-200/AAM-500
7. Author(s) ACD-200/210 AAM-500	8. Performing Organization Report No. DOT/FAA/CT-88/32
9. Performing Organization Name and Address AVIATION SAFETY DIVISION ENGINEERING, RESEARCH, AND DEVELOPMENT SERVICE FAA TECHNICAL CENTER ATLANTIC CITY INTERNATIONAL AIRPORT, NJ 08405	10. Work Unit No. (TRAIS)
	11. Contract or Grant No.
12. Sponsoring Agency Name and Address DEPARTMENT OF TRANSPORTATION FEDERAL AVIATION ADMINISTRATION	13. Type of Report and Period Covered PROGRAM PLAN
	14. Sponsoring Agency Code

15. Supplementary Notes

Subsequent revisions, amendments, or adjustments to this Program Plan will periodically be prepared, based on project additions (or deletions), major funding level changes, and schedule revisions.

16. Abstract

The Federal Aviation Administration's (FAA) National Aging Aircraft Research Program Plan describes planned research efforts designed to enhance aircraft and passenger safety through a better understanding of airframe and powerplant structural performance and maintainability including relevant human factors. The plan also identifies program participants and describes management tasks and schedules.

Program studies will focus on causes of in-service structural failures, such as fatigue, crack growth (including multiple site), debonding, and corrosion. They will also address failure detection, prevention, and remedies which will ensure continued airworthiness of the aircraft.

The program will include studies of pressurized airframe and engine fatigue and damage tolerance and practices. The impact of environmental factors, fabrication and maintenance techniques, operational stress/load cycles, and inspection practices will be investigated. Current nondestructive inspection (NDI) techniques will be assessed, and new, quantitative, automated NDI procedures will be developed. Human factors issues (human/equipment interface) will also be addressed. The major product will be technical data bases to support the generation of regulatory and advisory information.

17. Key Words	18. Distribution Statement
Structural Fatigue, Corrosion, Multiple-Site Cracking, Damage Tolerance, Nondestructive Inspection, Human Factors, Training	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified		

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EXECUTIVE SUMMARY

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1. NATIONAL AGING AIRCRAFT RESEARCH PROGRAM OVERVIEW.

1.1 INTRODUCTION.

The average age of the United States (U.S.) commercial air carrier fleet has increased from 4.6 years in 1970 to nearly 12.0 in 1985. Although chronological age alone does not directly measure the structural integrity or fatigue characteristics of an airframe or engine, it can alert users to the potential problems of engine and airframe fatigue when it correlates with high numbers of flight hours and flight cycles.

In 1981, a B-737-200 airplane (22020 hours, 33313 cycles, service entry May 1969) owned by Far Eastern Air (Taiwan) suffered an in-flight breakup with the loss of over one hundred lives. An investigation by the Government of Taiwan attributed the failure to corrosion-accelerated fatigue of fuselage skin panels. On April 28, 1988, multiple fatigue cracks caused an Aloha Airlines Boeing 737-200 transport (35496 hours, 89680 cycles, service entry April 1969) to lose part of its upper fuselage in flight, resulting in the death of a flight attendant and injury to many passengers.

The Federal Aviation Administration (FAA) convened an International Conference on Aging Airplanes in June 1988 which focused upon procedures to ensure continued airworthiness for today's aging commercial fleet. In view of the aforementioned occurrences, the expert consensus provided that, in addition to the operators performing maintenance and inspections with more diligence and thoroughness, the FAA should conduct research and development in technical areas associated with fatigue/multiple-site cracking, corrosion, nondestructive inspection (NDI), and human factors. As further support to this research need, Congress passed the Aviation Safety Act (Public Law 100-591) on November 3, 1988, stating that FAA (1) develop technologies and conduct data analysis to predict the effects of aircraft design, maintenance, testing, wear, and fatigue on the life of the aircraft, and (2) develop methods of improving aircraft maintenance technology and practices including NDI of aircraft structures. Resulting from these concerns and as contained herein, a National Aging Aircraft Research Program was initiated to include, in part, the following study areas:

- o Assessment of pressurized airframe and engine fatigue and damage tolerance technology and practices.
- o Investigation of the corrosion/environmental factors, fabrication and maintenance techniques, operational stress/load cycles, and inspection practices.
- o Evaluation of current and advanced automated NDI techniques and systems.
- o Review of human factor issues including human/equipment interface and performance.

1.2 PROGRAM OBJECTIVES.

The National Aging Aircraft Research Program consists of five major tasks designed to generate the technology needed to ensure the safe operation of aging U.S. commercial aircraft. The final product/objective of this program will be a comprehensive, technical data base that will support the development of new or the revision to existing regulations and advisory information and provide maximum protection of aging airframe and engine structures against catastrophic fatigue and/or corrosion failures.

The initial phase in this program will be to expand the current data base on fatigue failures associated with aging airframe systems and engine static structures in the present commercial fleet of fixed-wing transport airplanes (FAR Part 25). While much of the research is being performed for transport category aircraft, the resultant technology will be applicable to commuter, general aviation, and rotorcraft categories.

1.3 PROGRAM MANAGEMENT.

The National Aging Aircraft Research Program is managed by the FAA Technical Center's Engineering, Research, and Development Service, Aviation Safety Division, ACD-200. The technical focal point for the human factors tasks is the FAA Office of Aviation Medicine, Biomedical and Behavioral Sciences Division, AAM-500, under the auspices of this plan.

During the development stage of the aging aircraft issues, a number of groups/committees evolved which not only addressed specific issues but also provided requirements for this aging aircraft plan. These groups included:

- Oversite Expert Panel
- Industry Steering Committee
- FAA Management Team

This plan was drafted in concert with the findings of these groups/committees, and the FAA National Resource Specialists. Other Government agencies (i.e., NASA, DOD, etc.) major contractors, consultants, universities, and foreign organizations have contributed to the plan development.

1.4 TECHNICAL APPROACH.

To accomplish the objective and execute the technical tasks described in this program plan, the approach will be as follows:

- Review latest knowledge and data related to the causes, mechanisms, contributory factors, detection and remedy of fatigue failures in transport airframe and engine structures. Sources will include industry, Government, and academic data bases, research reports, technical journals, textbooks, and recognized experts in the appropriate specialty.

- Evaluate and adapt pertinent technology and procedures to FAA requirement needs.

- Initiate new R&D efforts as required.

- Validate all conclusions through analysis, testing, computer modeling, simulation, and operational experience. A critical sub-element here will be the development of suitable validation techniques where none exist.

- Institute and maintain clear and rapid lines of communication among Government and contractor project managements.

2. NATIONAL AGING AIRCRAFT RESEARCH PROGRAM TASKS.

The National Aging Aircraft Research Program is comprised of five major tasks; namely, (1) Program Integration, (2) Technology Transfer, (3) Structural Integrity, (4) Maintenance Inspection and Repair, and (5) Human Factors. These will be implemented concurrently to assure positive response to short, intermediate, and long term needs of the transport fleet. Furthermore, these major tasks consist of 29 projects as described in this plan, and individual projects can be modified/adjusted and new projects initiated as required.

Short-term research tasks will cover the initial 2 years. They will define the extent of the aging problem in transport airframes and engines and provide a basis for recommendations to the existing Supplementary Structural Inspection Program. Intermediate term efforts, which will extend over the first 5 years, will explain the failure mechanisms involved in aircraft fatigue (i.e., their causes, interactions, acceleration, modification) and will explore their detectability, predictability, and prevention. Long term efforts extending beyond the first 5 years will be devoted to the development of a Structural Life Management Plan that will provide assurance against unexpected fatigue failures for the design operating life of new airframes and engines. As part of this program activity, human factors experts will work alongside airframe and engine specialists and play a major role in this undertaking by reviewing the adequacy of past practices and developing new procedures appropriate to the engineering, manufacturing, and maintenance disciplines.

2.1 PROGRAM INTEGRATION.

The Program Integration task provides for management support of the National Aging Aircraft Program. The task will assure that major issues such as fatigue/multisite cracking, NDI, corrosion, and human factors are adequately addressed, and that needs appropriate to the certification, manufacturing, and maintenance/inspection offices are fully considered. Subtask activities will provide for (1) integrating/disseminating information between airframe, powerplant, and human factor disciplines, (2) funding/establishing and monitoring contracts, interagency agreements, and Memorandums of Understanding among Government, industry, and universities, and (3) scheduling and coordinating program task activities, as well as conducting workshops, seminars, meetings, and presenting task/management reports. Included within

the Program Integration task will be repetitive Aging Aircraft Symposiums aimed at reporting progress of industry (manufacturers, operators, and civil airworthiness authorities) and FAA research and development efforts. The first of these symposiums is scheduled for the spring 1990.

2.2 TECHNOLOGY TRANSFER.

The Technology Transfer task is aimed at providing an immediate response by implementing near term improvement actions through the transfer of technology from Government, civilian, and international institutions which have substantial applied experience in the field and technical areas involving fatigue, corrosion, and nondestructive inspection. Many of these organizations have already invested heavily in the study of these areas. Accordingly, they have extensive, ongoing research programs with results that can be tailored to commercial aviation applications. As a near term deliverable, all relevant military, civilian, and international data bases and technology will be identified, evaluated and, if warranted, modified and adopted for civil use.

2.2.1 Fatigue Tracking.

The major thrust of this subtask will be an extensive inquiry into the military's structural fatigue life tracking program with particular emphasis on pressurized fuselage such as the P-3A/B/C, C-135, and C-141 airplanes, and aircraft such as the B-52 which have had their original structural lives extended. The subtask will assess the military's use of onboard fatigue meters in aircraft, its collection and processing of recorded data, and its evaluation of fatigue life usage reports. A resulting detailed study report will document the aforementioned military philosophies and procedural approaches. The applicable military practices will be reviewed for use in commercial aviation. The results from this effort will provide (1) guidance to industry and FAA engineering and maintenance personnel in establishing structural fatigue life tracking and extension programs for new and in-service aircraft, (2) technical data to provide engineering and maintenance performance with a tailor-made program which accounts for route structure, and (3) recommended procedures to safely extend in-service aircraft life for new and in-service airplanes.

Milestones: Methodology Report - FY 91/Qtr 1
Feasibility Report - FY 91/Qtr 4

2.2.2 Corrosion Protection.

In view of the DOD's (especially the U.S. Navy) heavy involvement in airplane corrosion protection, this subtask would provide for the timely transfer of existing and developing military technology and expertise into commercial aviation; i.e. corrosion detection, repair, prevention techniques, inspection intervals, research limitations, and environmental restrictions. Relevant military corrosion detection and prevention technology will be reviewed along with existing civil requirements. Major areas of improvement will be identified for use by commercial airplane designers and maintenance personnel.

Milestones: Methodology Report - FY 91/Qtr 1
Feasibility Report - FY 91/Qtr 4

2.2.3 NDI Technology Survey.

At the June 1988 International Conference on Aging Airplanes, industry representatives suggested a need for greater standardization of NDI equipment and that current and developing NDI technology is generally not tailored to the needs of the aviation community. The purpose of this subtask is to transfer and adapt current NDI technology to the aviation industry. A survey involving field interviews, demonstrations, and correspondence will be conducted of DOD facilities (USAF/USN/USA). The survey will include a review of the interrelationship between NDI system effectiveness and visual inspection performance. Results will be in the form of a technical report containing current NDI equipment and techniques pertinent to aviation applications including their advantages and limitations with particular attention to the frequency and effects of false reporting. The report will benefit both the FAA and the aviation industry by packaging existing NDI technology and its current applications into a single document which can be periodically updated.

Milestones: Final Survey Report - FY 90/Qtr 4

2.3 STRUCTURAL INTEGRITY.

The objective of the Structural Integrity task is to (1) identify and assess those failure mechanisms that adversely affect the structural performance and safety of the airframe and engine system, (2) evaluate existing and new methods of structural analysis and tests that can be used by airplane and engine manufacturers to demonstrate compliance with the certification standards to insure the structural integrity of airframes and engines, and (3) develop improved maintenance, inspection, and repair techniques. New procedures that offer potential improvements in safeguarding structures against catastrophic fatigue failures will be identified and validated.

2.3.1 Structural Evaluation.

This subtask area provides for an assessment of the failure mechanisms, methodologies, and tests used to substantiate safe life, fail safe, and damage tolerant designs.

2.3.1.1 Failure Mechanisms.

2.3.1.1.1 Multiple-site Cracking.

Multisite cracking (MSC) has been associated with the two fatal aircraft accidents between 1981 and 1988. Experts contend that widespread MSC could invalidate the original fail-safe design features of the current pressurized aging fleet. Potential worse case MSC occurs when equal length cracks,

emanating from each side of a fastener hole in a row, join together and cause the structure to fail by net section yielding between crack tips. A need also exists to develop analytical methodology, supported by tests, to determine lead crack critical size in the presence of MSC ahead of the lead crack tip. The purpose of this project is to develop a technical data base (through testing and analysis) on the causes and effects of MSC. In addition, the effects of MSC on the current damage tolerance philosophy used to maintain and extend the service life of aging airplanes will be studied. Project results will be a handbook covering (1) fabrication techniques which avoid or minimize the potential for MSC, (2) maintenance/repair techniques for in-service airplanes exhibiting MSC, and (3) MSC detection and inspection criteria. The effort is expected to assist in the development of certification guidelines for addressing crack size, type, and orientation, and in the definition of inspection techniques and time intervals for the detection of MSC in the existing fleet.

Milestones: Damage Tolerance Handbook - FY 90/Qtr 4
Damage Tolerance Handbook with MSC - FY 93/Qtr 4

2.3.1.1.2 Corrosion, Crack Growth.

This project involves exploratory research supported by fatigue/static testing to determine the effects of corrosion on the crack growth rates of metal alloys typically used on commercial transport aircraft. The research is a follow-up to the work initiated at Cranfield Institute, Gatwick, England, where corrosion increased the crack growth rate of Aluminum 7178-T6 by a factor of five and crack growth rates of other materials as well. The feasibility of developing an analytical corrosion deterioration rate model based on these and other data will also be studied. The anticipated result of this project is expected to be technical data that can be applied to Supplemental Inspection Documents (SID's) and damage tolerance analysis.

Milestones: Preliminary Analysis Report - FY 93/Qtr 1
Final Analysis Report - FY 93/Qtr 4

2.3.1.2 Structural Safety Factors.

This project addresses the MSC problem using a simulation approach. Models will be developed to predict (1) the probability of a crack size with limit load or less capability, (2) the probability distribution for the crack size in detail before and after an inspection, (3) the probability of detecting a crack during an inspection, and (4) the cumulative probability of detecting a crack. No new test data are required, in that an adequate data base generated by prior tests exists for determining the feasibility of this approach.

This effort will contribute to the engineering and maintenance knowledge base needed for the continued safe operation of the aging airplane fleet and will provide personnel with a hands-on simulation technique for establishing realistic inspection intervals.

Milestones: Feasibility Report - FY 91/Qtr 3

2.3.1.3 Fatigue Analysis/Test Methodologies.

This project will provide a survey of fatigue analysis and test methodologies used by manufacturers. A data base will be developed consisting of identified fatigue tests, tear down, inspections and analytical techniques used to determine the intended service life for each in-service type airplane, each major component and each major structural modification. It will involve the investigation of current life testing techniques and practices and their application to service life substantiation and/or extension. In addition, the feasibility of requiring re-certification for service life extensions or mandating multiple lifetime fatigue tests on an individual model basis will be evaluated.

A summary report will document the procedures used in determining each in-service airplane's planned cycle/hours life. The report is expected to (1) assist FAA maintenance and engineering personnel in the analysis and establishment of service life extensions or limitation procedures for in-service airplanes, (2) improve the level of safety through the standardization of tests and analysis among manufacturers for new and in-service airplanes, (3) provide a technical basis for assessing service life extensions, and (4) provide a technical basis for updating certification standards for new airplanes.

Milestones: Preliminary Summary Report - FY 94/Qtr 1
Final Summary Report - FY 95/Qtr 1

2.3.1.4 Proof Pressure Testing.

Periodic proof pressure testing has been recommended in lieu of more comprehensive fatigue testing to substantiate the structural integrity of in-service aging airframes. The purpose of this project is to determine, through analysis and laboratory testing, the viability of using periodic proof pressure tests to ascertain the structural integrity of older airplane fuselages without damaging the airframe structure.

Milestones: Preliminary Feasibility Report - FY 90/Qtr 3
Final Feasibility Report - FY 91/Qtr 3

2.3.1.5 Documentation of Engine Static Component Condition.

A review of inspection/maintenance data over the last 5 years uncovered numerous repairs for cracked liners, casings, housings, and supports. A better understanding of the nature of these type of incidents and their impact on continued safe operation of aged engines is needed. This project will evaluate transport engine static components. Engines from selected airlines with different operational histories (high time, low time, high cycles, low cycles, and various combinations thereof) will be reviewed. Repair histories,

operational history, and environmental conditions will be considered. A technical report will identify factors affecting engine component condition and will provide the data needed to revise maintenance procedures and inspection intervals, and to determine life limits for engine static parts on in-service transport airplanes.

Milestones: Analysis Report - FY 91/Qtr 3

2.3.2 Structural Surveillance.

This subtask will provide the technology needed to track fatigue in individual aircraft and assess the feasibility of installing complete or partial fatigue monitoring systems in new aircraft. In addition, the typical commercial aircraft maneuver and gust loads environment will be more precisely characterized.

2.3.2.1 Flight Loads.

A review of existing flight data (mostly European) shows considerable differences in the load history usage among operators and individual airplanes. Average or typical expected load conditions are used to establish inspection intervals and modification times. Currently, such limits cannot be precisely tailored to specific airplane operations. Likewise, design criteria for future airplanes cannot be defined precisely. In addition to the research on pressurized fuselage loads, i.e. Aloha, a need exists to understand the gust effects of fuselage load environment, and the external loadings on other areas of the airplane, such as wing and empennage.

To achieve a more effective basis to establish structural modification and inspection intervals on new and in-service airplanes, this project will (1) reactivate and update the prior (NASA) flight loads data collection programs for L-1011, B-727, B-747, and DC-10 airplanes, (2) assemble and review flight loads data collected in Europe including CAADRP (CAA Data Recording Program), KSSU Airlines Group Program Swissair MD-80, (3) determine which airplane parameters should be monitored to define the fatigue load histories, (4) determine the cost/effectiveness of manually recorded data readouts versus electronic transfer of recorded data, (5) monitor the fatigue load histories of the selected in-service instrumented airplanes, and (6) develop an updated data base of typical operational parameters to be used to develop design criteria for future generation transport airplanes.

Milestones: Technical Data Reports Starting - FY 92/Qtr 1

2.3.3.2 Engine Life Cycling Requirements.

Since there are no current life limits for external engine static parts such as turbine and combustor casings, the effect of repeated repair is unknown. These elements are subject to thermal cycling in addition to stress cycling, thus, there is potential for hazardous failure. Characteristics of such elements

must be defined and understood in light of their unique operational use, thus studies of the factors that affect the life cycle of engine static components will be undertaken. Of special interest is the thermal cycling effect on the role of fracture mechanics, creep, and case hardening of combustor and turbine casings. This research project will provide certification support data on life cycle for selected engine static components, and establishment of repair limitations and inspection intervals for in-service engine static parts.

Milestones: Analysis Report - FY 92/Qtr 3

At the conclusion of the initial efforts, analysis of factors affecting the life cycle of the internal static parts of the engine will be expanded to include diffuser casings, bearing housings, support/mounts, and inner combustor liners of both commercial airline engines and commuter types. This follow-on effort will provide validated life cycle limits for certification use.

Milestones: Analysis Report - FY 95/Qtr 1

2.3.3 Structural Life Management.

This subtask area provides for a total life management plan which monitors, for each new aircraft, a predetermined system of actions from conceptual design throughout the service lifetime to ensure long and safe structural life.

2.3.3.1 "Cradle to Grave" Structural Integrity Program.

This project provides for a feasibility study which includes the development of a draft "Cradle to Grave" Aircraft Structural Integrity Plan ASIP for future commercial aircraft. The effort will be based upon determining the feasibility of adapting existing military ASIP aircraft structural integrity programs to civil aircraft. From a technical data base specified for each new aircraft, a planned system of actions will be identified to ensure a safe operational service life. This "Cradle to Grave" program will encompass a variety of engineering tasks including conceptualization, design, design criteria, analyses tests, material and manufacturing process, quality controls, flight tests, maintenance, and structural life management. The project's end product will be a feasibility report and technical data package consisting of a preliminary "Commercial Aircraft Structural Integrity Plan" (CASIP) for the FAA to consider for new aircraft. This product will provide an alternate philosophy concerning (1) integration of engineering and maintenance activities in assuring that the planned level of safety (i.e., intended service life) for each new aircraft is assured, (2) consistent provisions regarding the structural integrity of new aircraft, (3) technical data for developing policies regarding service life extensions of existing aging aircraft, and (4) assure proper transfer of inter-operator structural integrity related maintenance records.
Milestones: Feasibility Reports Starting - FY 92/Qtr 1

2.4 MAINTENANCE, INSPECTION AND REPAIR.

The Maintenance, Inspection and Repair task will provide for a review and update of current maintenance, inspection, and repair practices as affecting both airframe and engine structures. The major objective of the included subtasks and projects will be to develop an in-depth data base which identifies the problems and corrective actions that have been taken relative to ensuring proper maintenance, inspection and repair of the existing transport fleet, and to use this information to update current maintenance/inspection practices to include improvements in the present SSID program documents. The following subtask areas will include, but not be limited to, an assessment and development of this data base as appropriate to current visual and nondestructive inspection techniques, structural repair and modification practices, corrosion detection and prevention procedures, and new advanced NDI system technology. Results of this task will support the basis in which improved techniques and methods can be developed for airplanes operating up to and beyond their original intended service life.

2.4.1 Maintenance Practice Enhancement.

This subtask area provides for an evaluation of current maintenance, inspection and repair procedures used to ensure a safe service life of airplane and engine structures.

2.4.1.1 NDI Equipment Evaluation

In support of the operator's major visual inspection program, a multiple number of NDI techniques may be applied such as the use of ultrasonics and eddy current systems. As applied to lap joint splice areas of older airplanes, one of the primary concerns is the need to assess state-of-the-art equipment used in the determination of metal-to-metal bond integrity. Also, while in most cases single methods of NDI are sufficient, instances arise where dual inspection methods may be required to attain minimum detectability requirements. Variation of structural designs further complicate the determination of the appropriate NDI equipment/methods to be used. In addition, experts disagree on both the maximum undetectable flaw (crack) size capable of being detected and the NDI equipment's ability to reliably detect corrosion.

The purpose of this project is to (1) assess equipment used to determine the integrity of metal-to-metal bonds, (2) answer some of the aforementioned concerns relating to the multiple NDI system selection, (3) evaluate the NDI usage and effectiveness on various configurations of new and aged civil aircraft, and (4) review the relationship, use and effectiveness of current visual inspection to existing NDI system performance. Some of the factors to be considered will be ease of usage, detection, false readings, and response of equipment. This project will also interact with the Human Factors projects (para 2.5), and will use the data generated under the NDI Technology Survey project (para 2.2.3). The output from this project will be a report addressing various techniques of applying and collecting data using NDI equipment

including portability, ease of recording, and accuracy. Data generated will be available for use to upgrade current advisory material. This effort will use both industry and FAA personnel with needed experience and familiarization with the applications/usage of NDI equipment under a variety of conditions.

Milestones: Assessment Report - FY 89/Qtr 4
Final Report - FY 91/Qtr 4

2.4.1.2 Engine Nondestructive Evaluation.

Engine static parts such as turbine cases, diffuser cases, and combustor liners do not have fatigue life limits, and therefore are not subjected to detailed, scheduled inspection. Rather, such cracking is usually identified as a result of engine out-of-limits operation or poor performance. Application of proper inspections would result in detecting such problems before an engine is required to be removed because of part(s) failure.

Two activities will be implemented under this project. Under one activity, airline current engine nondestructive and testing techniques for static components will be reviewed and analyzed. Quality assurance principles will be applied to identify areas of potential problems and areas where improvement in equipment or techniques is needed will be identified. A report on effectiveness of operator engine/NDI techniques and a report on improved equipment requirements will provide improved inspection techniques/procedures leading to improved safety of in-service engines.

Milestones: Effectiveness Report - FY 91/Qtr 1
Equipment Requirements Report - FY 92/Qtr 2

The second activity identified in this engine NDI project area concerns the use and application of microsensors for detecting cracks in inaccessible areas. Under this project activity onboard microsensors capable of sensing metal case hardening, or changes in ultrasound signatures as cracking develops will be investigated for use on in-service operating engines. Computerized integration of the output from these sensors with the aircraft data systems will be investigated for use as a real-time cockpit monitoring system. This effort is expected to result in prototype microsensors for engine static components and breadboard computerized sensor analysis system. These will improve inspection/detection capability of inaccessible areas.

Milestones: Effectiveness Report - FY 93/Qtr 1
Sensor Development - FY 93/Qtr 1
Sensor Analysis System - FY 95/Qtr 1

2.4.1.3 Engine Repair Practices Evaluation.

This project involves an evaluation of current and static engine repair practices to determine how (and to what extent) nonuniform repairs affect engine life. Frequently, engine maintenance is not performed by the operator

and, as a result, variations in the repair or maintenance programs exist, and these may potentially be the cause of fatigue cracks going undetected. This research effort will provide for detailed documentation and analysis of selected operator engine inspections, repairs, and maintenance practices. The evaluation will include an investigation of the potential differences that can occur as a result of such repair/maintenance being accomplished in-house or under contract to another operator or independent repair station. A technical report documenting potential repair/maintenance problems will be prepared to assist industry and FAA maintenance personnel to identify the maintenance/ repair problems that can degrade safety for both in-service transport and commuter engines.

Milestones: Analysis Report - FY 91/Qtr 1
Air Carrier Problem Report - FY 93/Qtr 1
Commuter Problem Report - FY 92/Qtr 3

2.4.1.4 Corrosion, Detection, and Prevention.

As an initial step in ascertaining the extent of corrosion damage in the current U.S. civilian fleet, this project will emulate a recent DOD feasibility study by developing a comprehensive commercial aircraft corrosion assessment data base. Information obtained under the Technology Transfer task (para 2.2.2) will be supplemented with the acquisition of available operator and manufacturer corrosion-related findings and reports; and an interactive data base consisting of airframe and component, major repairs, and failures will be established and analyzed.

This commercial aircraft corrosion analyses data base will (1) provide guidance for future corrosion failure analysis on new and in-service airplanes, (2) focus design engineering efforts into areas where significant improvements are needed and to determine when materials need replacement, (3) provide maintenance and inspection personnel with a prioritized inspection procedure, based on the failure analysis results, (4) provide basis for determining the manner in which manufacture recommended corrosion protection procedures are followed, and (5) provide technical data from which current maintenance procedures, SSID, and service bulletins can be updated.

Milestones: Preliminary Technical Report - FY 89/Qtr 4
Interim Data Base(s) - FY 90/Qtr 4, FY 91/Qtr 4
Complete Data Base - FY 92/Qtr 4

Follow-on activities will focus on the development of onboard corrosion sensor technology and the establishment of a geographical corrosion classification system for major centers of air traffic activity. This research will provide (1) quick, reliable identification of exfoliation corrosion under lavatories and other inaccessible locations, and (2) more precise inspection criteria accounting for environmental effects.

Milestones: Preliminary Technical Data Base - FY 93/Qtr 1

2.4.1.5 Operational, Maintenance and Inspection Review.

This project represents a major activity under the Maintenance Practice Enhancement subtask. The magnitude of the maintenance, inspection, and repair problems of aging aircraft measured in terms of fatigue, corrosion, and debonding are not yet fully understood. Often, there is concern that proper technology may already exist but is not applied as recommended or has yet to be identified. Subject work effort will compile maintenance history data into a technical data base which includes owners/operator history, numbers of flight hours, pressurization cycles, history of geographic location, inspection service bulletins, repairs, and modification history as a basis for evaluating in-service experience and the effectiveness of current maintenance, inspection, and repair procedures. This effort will provide technical data input for the Structural Integrity (para 2.2) and Human Factors (para 2.5) tasks. This effort will benefit both the FAA and the aviation industry by providing operating history information (environment, age, etc.) as a function of such key variables as materials, manufacturing, and maintenance/repair practices.

Milestones: Preliminary Data Base - FY 93/Qtr 1
Final Data Base - FY 93/Qtr 4

2.4.2 New Technology

This subtask area provides for investigation and development of new quantitative, automated, and semi-automated NDI equipment including robotics. This new equipment would minimize the uncertainty about what crack size might actually exist in an airframe after an in-service inspection. These techniques would have the potential to limit or totally remove the human element from the visual and nondestructive inspection process.

2.4.2.1 NDI Advanced Systems Development.

The objective of this project is to investigate and develop quantitative automated or semi-automated NDI equipment including the use of fiber optics, thermal flux computer-enhanced signalling, artificial intelligence applications, and robotics. This effort will be coordinated with the Technology Transfer task (para 2.2.3) and the Human Factor's task (para 2.5) to avoid duplication of efforts and result in prototype automated systems and design specifications to enhance the NDI of in-service aging airplanes. Handbooks detailing the usage of each system will be provided. Result of this effort may benefit design engineers and maintenance/inspector personnel because it has the potential to enhance visual inspection limitations and to improve detection reliability rates while minimizing costs and airplane down times.

Milestones: System Handbook(s) Beginning - FY 93/Qtr 1

2.5 HUMAN FACTORS.

The Human Factors issue addresses the precise and timely implementation of the damage tolerance, corrosion, fatigue, and NDI technology described in prior sections of the program plan. Specifically, these human factors tasks provide for an in-depth review and validation of current airframe inspection training and work practices used by industry and the FAA. In addition, it is targeted at the identification of awareness and resolution of needs associated with the human/equipment interface and, specifically, those areas that concern both designer and maintenance/inspection personnel. Subtasks will focus upon human performance issues in maintenance and inspection. Various topical areas will be studied including error analysis, training and work environment concerns, equipment design, human limitations and selection, placement and motivation issues. Results will be combined with knowledge from other sources, such as medical and physiological information, to produce a handbook containing a compendium of information for use by designers, manufacturers, airline maintenance organizations, and the FAA. The information from this handbook will permit these groups to accomplish their respective responsibilities in an optimal fashion by recognizing and dealing with human performance capabilities and limitations. As provided under the human factor task, the included subtask activities are identified as follows.

2.5.1 Task Analysis.

Under this subtask, the study of human factors of maintenance and inspection will be initiated by analyses of various procedures considered to be crucial to the continued airworthiness of aging airplanes. Analyses consist of careful study, observations, and identification of component and subtasks of larger task units. This information is critical to development of training, communication, and work environment recommendations.

Milestones: Final Report - FY 89/Qtr 2

2.5.2 Training Design.

Using experience gained in other industrial settings, new training module recommendations will be developed under this subtask for the error-prone search phase of inspection. This may include training in optimal research strategies and use of computer-assisted cuing.

Milestones: Final Report - FY 89/Qtr 2

2.5.3 Equipment Design.

Existing equipment, including NDI equipment, frequently shows lack of human factors engineering impact in its design. It is necessary that such equipment be designed and used with recognition of human capabilities and limitations. This subtask will produce guidance for equipment designers and operators.

Milestones: Final Report - FY 91/Qtr 4

2.5.4 Environment Design.

An inspector's job is usually performed under time pressure, yet the speed/accuracy tradeoff is strong. This can lead to job stress and reduced performance. Both stress and performance need to be evaluated on-the-job under different levels of time pressure. Other important job factors include access lighting, noise, and temperature. Under this subtask all of these factors will be researched in the field and laboratory for a complete understanding of how they can shape and hence be controlled to the benefit of the inspection process.

Milestones: Final Report - FY 92/Qtr 3

2.5.5 Job Performance Aids

This subtask will evaluate existing and planned devices and systems in use elsewhere for application to the airplane inspection process. The U.S. Air Force at Wright Patterson has developed and continues to develop computer-based systems which provide on-line visual and audio instructions on maintenance and inspection procedures. These systems also provide exploded views of aircraft substructure and parts inventories. Human factors study is required to research the integration of the job aid with the task and to develop job aids to fit the civil airplane inspection function.

Milestones: Final Report - FY 91/Qtr 2

2.5.6 Selection/Placement/Motivation.

This subtask will study the relationship among motivational and other personnel characteristics, job performance, and job stress. Possible result may be identification of variables which point to higher likelihood of success in the inspection role. This work may involve development of pencil/paper test and other selection methods.

Milestones: Final Report - FY 92/Qtr 3

2.5.7 Human Error Classification.

This subtask provides for the analysis and classification of human error in aircraft maintenance and inspection.

Milestones: Final Report - FY 91/Qtr 3

2.5.8 Detection Theory.

Signal detection theory is a probable approach to describing ability to detect "signals" in "noise" background. In the aircraft inspection case, a signal could be a defective rivet in a noise field of thousands of normal rivets. Other analogies abound. This subtask will attempt to apply existing theory and knowledge from other research to the airplane inspection case.

Milestones: Final Report - FY 91/Qtr 4

2.5.9 Computer Base Simulation.

This subtask area recognizes that current instructional methods often may be inefficient or ineffective and could lead to unsafe practices. Much training is currently accomplished on an OJT basis where "learning from mistakes" prevails. This activity will study various CBT methods and applications to airplane maintenance and inspection functions.

Milestones: Final Report - FY 91/Qtr 4

2.5.10 Handbook Development.

A comprehensive human factors handbook covering the above subtask elements will be developed under this subtask for use by maintenance and inspection technicians and managers, as well as designers, manufacturers, and FAA personnel. The handbook will deal with such issues as vigilance, physiological and anthropomorphic considerations, equipment, work environment, and training needs.

Milestones: Final Handbook - FY 93/Qtr 4