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MAINTAINING THE SAFETY OF AN AGING FLEET OF AIRCRAFT

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The current status of the Douglas Aging Fleet is examined in light of increasing concern for the possibility of the onset of widespread cracking and recent industry activity to minimize the concern. A fleet monitoring program together with an augmented maintenance program is proposed as a possible means to reduce the concern. Six candidate options for maintenance program augmentation are examined which have been shown to be effective in detection of widespread fatigue damage. A brief example of how this system might be applied to the DC-9 Fleet is presented.

INTRODUCTION

The prospect of aircraft being operated for extended periods of time is clearly upon us. It seems that modern technology and ingenuity has kept our modern jet fleet intact and economical to operate far beyond what was envisioned at the time the aircraft was first certified. Well over 2500 aircraft, worldwide, are beyond their original 20 year design life goal. But are these aircraft structurally safe for such operations? Or will there be an increase in the number of accidents like the one in April of 1988, in which a portion of the forward fuselage of an aircraft separated due to undetected widespread structural degradation? This paper presents one manufacturer's viewpoint on the means to maintain the safety of an aging fleet of aircraft against such structural degradation.

DOUGLAS AGING FLEET

Figure 1 shows the current statistics for the Douglas fleet of jet aircraft. A total of five different models are in service around the world. As of July 1, 1991 nearly 2900 aircraft have been produced, of which over 2500 are currently active, 175 have been retired, and 139 have been destroyed. Of the active aircraft, 1170 have exceeded their original design life goals in terms of flight hours, landings and/or length of service. DC-8 Fuselage Number 13 has currently accrued 32 years of service. This represents service life greater than 1.5 times the original estimate of 20 years. In fact the average aircraft in the DC-8 and DC-9 fleet has exceeded the 20 year goal originally established. DC-9 Fuselage Number 12 has exceeded 93,000 landings, well over 2.25 times the original design goal of 40,000 landings. DC-10 Fuselage Number 117 has exceeded 77,000 flight hours which represents nearly 1.3 times the original design life goal of 60,000 flight hours.

Of the 2500 active aircraft, not one has reached its test supported life. This life equals the tested landing life divided by a scatter factor of two and is generally considered to be the life beyond which the fatigue behavior of the fleet is not proven. Aircraft operated up to this point should be relatively free from widespread fatigue cracking.

Aircraft operated beyond the test supported landing life require a greater level of surveillance in order to protect them against the potential effects of several forms of widespread fatigue damage. This concept is shown in Figure 2 for the DC-9 Fleet. Based on statistical inference, the projected life of the fleet is

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considerably beyond the test supported life. This gives rather strong evidence that the DC-9, barring any unforeseen economic or regulatory issues, will be in use for some time to come.

ECONOMIC ISSUES

The cost of operation has historically been the deciding factor in when to retire an aircraft. In recent times the cost of fuel has moderated. This, coupled with the availability of a whole host of performance improvement items such as re-engining programs, the addition of winglets and electronic engine performance monitors has made the older aircraft as or more economical to operate as acquiring new generation aircraft. Barring any unforeseen down turns in the economy, there is no evidence that aircraft will be retired in the near future for economic reasons.

INDUSTRY AND REGULATORY INITIATIVES

Damage tolerance requirements were introduced to the industry in 1978. Figure 3 presents a time line of significant regulatory and industry initiatives for structural design since the advent of these requirements. More recently, following the April 1988 accident, operators, manufacturers, and regulators began developing a series of programs to reduce the future probability of a similar event. These are also reflected in Figure 3.

Industry initiatives. In August of 1988, the Air Transport Association (ATA) and Aerospace Industries Association (AIA) in cooperation with the Federal Aviation Administration (FAA) established the Airworthiness Assurance Task Force (AATF). The AATF was commissioned to evaluate the deficiencies in the system that lead up to the April 1988 accident and to propose both industry wide and model specific actions to fix the system. To date the AATF has instituted programs dealing with:

1. Mandatory modifications for termination of repetitive inspections for certain critical service bulletins.
2. Industry-wide mandatory corrosion prevention and control program.
3. An industry guide on proper maintenance programs for aging aircraft as well as model specific guidance.
4. A periodic audit of the Supplemental Inspection Documents(SID).

Additionally, the AATF is currently working on proposals dealing with repairs to aircraft and improved industry communication.

The AATF programs provide a means to upgrade an aircraft at a specific point in its life to insure that the the original fail safe design principles are intact on an aircraft by aircraft basis. This insures that the first line of defense against all forms of structural degradation is still effective. These programs are only marginally effective, however, in the prediction or prevention of the onset of widespread fatigue damage.

Regulatory initiatives. In recent years the FAA has proposed rule making in two areas which may limit the useful life of the older aircraft.

In response to the April 1988 accident, the FAA independently proposed a series of new rules to further reduce the chances of having another similar accident. The proposed rules embrace a fatigue testing concept to protect the fleet against the onset of widespread fatigue damage and are directed towards new certification programs as well as retroactive fatigue testing for aircraft already certified.

The AATF as well as the AIA have initiated independent reviews of the proposed rules to assist the FAA in arriving at appropriate rule making material. Preliminary results of the industry reviews indicate that while fatigue testing is appropriate for new certification programs it is not appropriate, in and of itself, to protect older aircraft against the onset of widespread fatigue damage. Specific rules requiring fatigue testing of older aircraft may mean the premature and unnecessary retirement of many aircraft.

In addition to the safety related proposed rules, the FAA has also recently proposed new noise related rules which will accelerate the phase out of noisier Stage 2 aircraft by the year 2000. The enactment of these rules may have a significant effect on reducing the size of the aging fleet in the near term. Figure 4 shows the comparison between the current scheduled phase out and the new proposed rule.

Although economics and regulatory issues may have an impact, many first and second generation jet aircraft will be in extended operation for some time to come. In operating these aircraft, there are concerns, both perceived and factual, about structural integrity that need to be addressed. Those concerns center around the timely detection of widespread fatigue damage.

DAC AGING AIRCRAFT PROGRAMS

Douglas, with the cooperation of operators and regulators throughout the world, has developed five interrelated programs to identify and address issues that are generic to an aging fleet of aircraft. These programs, are shown in Figure 5.

Some of these programs are passive in that they act as a source of data to monitor the fleet. These programs include the Extended Fatigue Test Programs and the Douglas Design Evaluation Program. The data from these programs are used to adjust, as necessary, active programs. Active programs include the Supplemental Inspection Document program and the AATF initiatives discussed earlier. These programs are active in the sense that they perform specific tasks on aircraft in the fleet. Training, which is interactive, is also included amongst the programs because there is, as always, a need to insure a common level of understanding about the programs across the industry.

All of these programs establish a basis which supports the timely detection of all forms of structural degradation. Figure 6 depicts the interaction that is needed between the the various parts of the industry to insure the structural integrity of the aircraft. Each party has its own specific role in assuring that integrity. The manufacturer supplies the necessary technical support in evaluating service findings. The operator is ultimately responsible for the maintenance of the safety of the aircraft. And the regulator insures that the regulations are being followed by both the manufacturer and the operator and insures compliance with critical safety issues. The key ingredient to this system is communications between all of the parties.

WIDESPREAD FATIGUE DAMAGE

Widespread fatigue damage is best understood by looking at a structural life concept that embodies damage tolerance principals as shown in Figure 7. Damage tolerance principals often assume the presence of discrepancies in structure to facilitate the analysis procedure. These discrepancies are known as equivalent flaw sizes and in fact account for a number of variables in the manufacturing and assembly process.

As aircraft are being manufactured, quality control procedures insure that the finished products are essentially free from structural discrepancies. Discrepancies that do slip by the quality control procedures are generally sub-detectable and random in nature. The larger of these discrepancies (some times known as a rogue flaw), if located in a critical area, could ultimately become a fatigue crack and grow to a critical size at some point in the aircraft life. In the design of a new aircraft, the crack growth design life goal for the rogue flaw is normally set at a life greater than the design life goal of the aircraft. The program described by the Supplemental Inspection Document is designed to find and correct such flaws before they reach critical size.

The smaller discrepancies, known as initial quality flaws, initiate fatigue cracks and grow at a much slower rate but are much more frequent in occurrence. This leads to the idea that there are many discrepancies at many locations growing simultaneously which may ultimately lead to a failure condition. These smaller discrepancies are more likely to be a concern on configurations that are highly repetitive, such as the rows of rivet holes in a high load transfer splice. In the most extreme case, structural failure occurs by net section yield along a line of small cracks that are only marginally detectable. This describes the most classic form of widespread fatigue damage. Fatigue test of a full scale component to at least two design lifetimes followed by a teardown inspection is normally used to rule out this form of structural degradation for newly certified aircraft.

There are two specific forms of widespread fatigue damage that are of potential concern to the aging fleet of aircraft. The first is known as Multiple Site Fatigue Damage (MSD) and the other is known as Multiple Element Fatigue Damage (MED) (see Figure 8).

MULTIPLE SITE FATIGUE DAMAGE (MSD)

MSD is fatigue damage that principally occurs in highly repetitive design details such as rivet holes in splices and is generally limited to one principal structural element such as a wing or fuselage skin panel.

MULTIPLE ELEMENT FATIGUE DAMAGE (MED)

MED is fatigue damage that occurs in multiple stiffening members that support the skin panels causing the fail-safe properties of the design to be downgraded through loss of strength in similar adjacent stiffening elements.

DESIGN ISSUES

Careful design supported by testing can assure an aircraft has a long life free from widespread cracking. Proper attention to material selection and detail design standards for areas of load transfer with uniform high stress levels can mean a design that is essentially free from MSD or MED for its intended life.

The DC-9, currently in its third lifetime of operation, is a good example of this. In 1981 Douglas re-purchased DC-9 Fuselage Number 3 for extended fatigue testing to insure an adequate fatigue margin of safety for extended operations. At the time, it was one of the five highest time aircraft having accumulated over 66,500 landings. It was in regular airline service and was accruing landings at the rate of 3500 landings a year. It was scheduled for a major structural maintenance check (D check) within a month. After the aircraft was flown to Douglas Aircraft Company in Long Beach California, it was stripped of all interior items and a thorough inspection of the structure conducted. After a total of 15 years of service, the structure was found to be remarkably free of corrosion and fatigue cracks. The problem areas that were found were either repaired or tagged for careful evaluation as the test progressed. Certain service bulletins were selected for incorporation before the test began.

The program extended the tested life on the DC-9 fuselage structure from 125,000 flights to over 208,000 flights. At the end of the test an extensive evaluation of the structure was conducted including the 'tear down' of over twenty-two feet of fuselage longitudinal lap splice. Over 8000 individual rivet holes were checked for fatigue cracks with no findings reported. In addition, after fifteen years of service and five years of testing, there was no reported corrosion found in the faying surface. Additional coupon type fatigue tests on the wing and empennage structure extended the tested life of these components to over 208,000 flights.

MAINTENANCE ISSUES

When an aircraft enters service it is the responsibility of the operator to perform routine maintenance checks in order to detect and correct damage or deficiencies in a timely manner. The requirements of most regulators stipulate that an acceptable maintenance program must be in place before the airline initiates service with the aircraft. At the time of certification the manufacturer, with help from the customer airlines and the regulator, publishes an initial maintenance program which can be used as an acceptable guide to the development of individual airline maintenance programs. The structural maintenance stipulated in this initial program is based on visual detection of structural degradation. This concept did not come about by chance but is based on the fail-safe design principals required by regulators and insisted upon by operators. Figure 9 shows an example of what is meant by visual detection of structural degradation. In this particular example, any cracks developing in the exterior skin at rows B or C are acceptable. Cracks that develop in any other manner are unacceptable.

DAC assures visually detectable modes of failure in aircraft design details through a combination of coupon, sub-component, and full scale fatigue tests. As a note of interest the DC-10 full scale fatigue test was delayed for a number of months because of a hidden failure that developed in one of the splice joints in a component test. As a result of the failure, a new design was developed and tested in another component test to verify its failure mode prior to incorporation of the design modification into the full scale fatigue test.

The primary issue here is that widespread fatigue cracking may not be visually detectable before failure (see Figure 7). Because of this, a competent program must be in place to insure the timely detection of widespread damage as the aircraft age.

AN INDUSTRY APPROACH TO DETECTING WIDESPREAD FATIGUE DAMAGE

As part of the original Airline/Manufacturer Recommendations (1) following the April 1988 accident it was recommended that the industry "Continue to pursue the concept of teardown of the oldest airline airplane to determine structural condition, and conduct fatigue tests of older airplanes......". In June of 1990 the AATF commissioned an International Task Group of operators and manufacturers to investigate and propose appropriate actions based on this recommendation. The AATF further stipulated that the investigation should place special emphasis on the ability of the actions proposed to discover widespread damage in a timely manner.

The Task Group, composed of six manufacturers and five operators, worked closely with regulators from four countries to develop appropriate actions for the aging fleet. The Task Group reached seven major conclusions and six recommendations during its eight month study and published a 190 page report.* The primary conclusion reached was that while significant improvements in the structural safety system have been introduced by the AATF programs, there is still an outstanding concern for the potential onset and possible non-detection of widespread fatigue damage. The report further went on to recommend that it is appropriate to perform a model specific audit of those aircraft that have exceeded or are about to exceed their original design life goals with respect to the programs already in place to determine if any concerns exist that require additional actions. This audit would be monitored by an Industry Oversight Group to insure that audit of each model is consistent with industry norms.

THE MODEL SPECIFIC AUDIT

In consideration of the potential consequences of widespread fatigue damage, it is important to assess the likelihood of its occurrence on a given airplane and the ability of the current maintenance system (as modified by the SID, manufacturer and AATF programs) to discover the damage in a timely (safe) manner. In order that this is done in a logical and consistent manner across the industry, the Task Group proposed the audit process, shown in Figure 10, be applied to each candidate fleet of airplanes after full definition of all the aging aircraft related activities. This process would be conducted in the AATF Structures Working Group environment with operators, the airplane manufacturer and the regulators fully involved. Specific courses of actions developed by the Structures Working Group would be integrated into the aircraft maintenance program through a Service Bulletin, SID update, or changes to the model specific aging aircraft maintenance guidelines.

CANDIDATE MODEL SPECIFIC ACTIONS

The Task Group performed an extensive data collection and analysis activity to determine candidate options that have applicability to the identified concerns. This activity centered around the past manufacturer, operator and regulator experience with the related areas.

The activities of the Task Group formed the basis for the development of alternative options to resolve any residual concern for the potential of widespread fatigue damage in a fleet of aircraft. The effort also

* ATA Report, 'A Report of the AATF on Fatigue Testing and/or Teardown Issues', Unpublished - please contact the Air Transport Association, Washington DC, for a copy, February 1991

served to provide some common ground to assess the benefits and limitations of each option as well as the ground rules under which each option should be considered.

All of the options adopted are valid to one degree or another in predicting the onset and location of multiple site damage and multiple element damage, but none of the options are foolproof. The potential consequences of multiple site and multiple element damage dictate the need for safeguards that will provide a high degree of confidence that it will not happen. Ultimately this will depend on conscientious and reliable inspections of the aircraft structure.

A total of six options were identified as possible candidates to be used to alleviate any residual concerns. These options can be viewed singly or in combination to develop the required level of safety. The options identified are shown in Figure 11 and discussed below.

Selected limited non-destructive disassembly and refurbishment of high time airplanes continuing in service. This option would allow a manufacturer to identify specific areas of an airplane that may be susceptible to multiple site damage or multiple element damage for an increased level of surveillance during scheduled maintenance visits. Candidate airlines and airplanes would be targeted for partial disassembly in the areas identified to facilitate inspections for emerging structural degradation. This process would allow smaller damage levels to be found than would be found by non-disassembly techniques. This option has distinct advantages over other options because of lead time and resources required to implement the process. In general, it is believed that this option would be able to supply the largest volume of the highest credibility data for assessment of structural condition.

Continuing assessment of the fleet demonstrated capability through diligent monitoring of service experience. This option has been successfully used in the past to predict future behavior of the fleet by statistical inference. The process examines the characteristic shape of a histogram representing the fleet of aircraft. Given a statistical theorem (e.g. Weibull or Log-Normal), it is possible to project the mean life of the fleet and then determine the proven life based on some predetermined criteria (either one crack in the fleet or sometimes a predetermined failure rate). This process, used with other options discussed here, can become a powerful tool in predicting the onset of widespread cracking.

Fleet exploration of high time airplanes with improved and state of the art NDI techniques. This option is clearly something that is focussed for the future. The viability of this option lies with the research and development initiatives of the FAA and NASA and to a certain extent on developments in the human factors area. It is included here because it is expected that the developments in the NDI area will be evolutionary rather than revolutionary. The process of evaluation should always be ready to accept innovative concepts as they are introduced especially if they save time and increase accuracy.

Testing of new or used structure on a smaller scale than full component tests, i.e. sub-component and/or panel tests. This option represents another method to evaluate the inherent capabilities of a particular design as far as susceptibility to multiple site damage and multiple element damage is concerned. This option allows a rapid assessment of various repetitive design details at a nominal cost in resources.

Extended full scale fatigue test and teardown. This option requires a significant investment in resources and time but does provide significant insight to future fatigue related behavior of the airplane design including modes of failure and probable locations and would allow adjustment of maintenance programs accordingly. There are concerns about how representative a single test of a particular airplane is to the whole fleet, and the amount of time required to complete the testing, teardown and release the results to the operators. There is also a significant concern associated with current popular connotation of fatigue testing setting a safe life on the airframe.

Airplane teardown. This option allows opportunistic destructive teardown inspections of airplanes, that for some reason, have been removed from service. This option allows a detailed piece by piece examination of each component of an airframe to discover structural degradation and establish structural condition. The process can identify suspect areas and project future structural performance. Fractographic analysis of the structure, post teardown, can be used to enhance the value of the teardown inspection. There is a significant concern of how representative the tear down of a particular airplane is of the whole fleet. The option requires a considerable investment in resources but can be completed in a reasonable time frame.

The Task Group Report (2) has been officially transmitted to the FAA and they are currently considering the merits of the report's conclusions and recommendations.

MONITORING THE FLEET

The key element in the implementation of the model specific audit requirements is the monitoring of fleet findings in a timely and expeditious manner. Figure 12 shows how the fleet findings might be monitored in a flow chart form. The Structures Working Group would propose model specific audit requirements. These audit requirements would then be implemented either by augmenting the SID programs, issuance of service bulletins or the manufacturer would start a fatigue test. Operators owning designated aircraft would then be required to modify their maintenance programs in accordance with the recommendations of the Structures Working Group as endorsed by the Regulator. Findings would be complied as a result of the inspections and acted upon when warranted. This procedure is not unlike the current procedure used for the Douglas Aircraft Company SID programs.

MAINTAINING SAFETY

If the key element in the audit program is the monitoring of fleet findings, the second most important element is the interpretation of the findings. In the formulation of the audit program there must be a conscientious evaluation of the ability of a particular action to identify problems in terms of what is already known about the fleet of aircraft. In reality this is a modification of the fleet demonstrated life approach (Item B) shown in Figure 11.

At Douglas Aircraft Company, the accepted convention for maintaining safety for potential problems is a probability of 90 percent detection before there is possibility of exceeding a Failure Rate (FR) of 1×10^{-9} on a per flight basis. The probability of not exceeding the failure rate is the basis of selecting the appropriate candidate option and the frequency of application considering routine maintenance and the current SID. It is important to point out that these areas have no known history of fatigue cracking and findings as few as one can initiate the fleet protection program.

An example of how this system might work for the DC-9 fleet is shown in Figure 13. Each design detail/area under consideration has its own estimated mean fatigue life (N_{ainst}) based on fatigue tests or other comparable means. Using a failure rate as a basis, a life (N^{TH}) can be calculated using the statistical equation:

$$FR = \frac{p(N^{TH}+1)-p(N^{TH})}{1.0 - p(N^{TH})} \qquad (1)$$

Where $p(N^{TH})$ is the log-normal probability of having a crack $a \geq a_{inst}$ at N^{TH} based on the estimate of mean life and the standard deviation (s). This failure rate represents only the possibility of having a crack of critical length. This value must be multiplied by the probability of encountering limit load to arrive at the 1×10^{-9} joint probability.

Using the estimate of mean life, the standard deviation and the current fleet statistics, it is possible to estimate the total population of cracks in the fleet for a given design detail. As shown, the life represented by N^{TH} is somewhat in advance of the lead aircraft yet there is a distinct probability of the presence of 2.3 cracks in the active DC-9 Fleet, if the estimate of mean life is correct. Fleet safety is assured if there is a 90%

probability that the maintenance programs will detect the emerging cracks in the candidate fleet (shown shaded in Figure 13) before the lead aircraft reaches N^{TH}. Negative findings (e.g. inspections that find no evidence of fatigue cracking) provide the basis for extending the useful life of the aircraft. Positive findings, on the other hand, provide the basis for a fleet protection program.

CONCLUSIONS

Barring prohibitive economic or regulatory issues, the fleet of aging aircraft will continue in service for many years to come. As these aircraft age there is an increased likelihood of widespread fatigue damage. The concerns associated with the possibilities of the onset of widespread damage require competent programs to insure that this form of structural degradation is discovered in a timely manner. A model specific audit can identify areas that have a potential for future development of widespread damage. An augmented maintenance program similar to the program offered in the Supplemental Inspection Document can then be formulated on an area by area basis using one or more of the following options:

A. Selected limited non-destructive disassembly and refurbishment of high time airplanes continuing in service.

B. Continuing assessment of the fleet demonstrated capability through diligent monitoring of service experience.

C. Fleet exploration of high time airplanes with improved and state of the art NDI techniques.

D. Testing of new or used structure on a smaller scale than full component tests, i.e. sub-component and/or panel tests.

E. Extended full scale fatigue test and teardown.

F. Airplane teardown.

Inspection conducted in the fleet under the augmented maintenance program can then be compared to the expected fleet behavior. Results of this comparison will provide the necessary information to increase the life of the fleet or begin a fleet protection/modification program.

ACKNOWLEDGEMENTS

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SYMBOLS USED

AATF	=	Airworthiness Assurance Task Force
AIA	=	Aerospace Industries Association
ATA	=	Air Transport Association
$a_{detectable}$ or a_{det}	=	Detectable crack (or flaw) size associated with a 90% probability of detection, for a given Nondestructive method
$a_{instability}$ or a_{inst}	=	Crack size at onset of rapid propagation, corresponding to 100% limit load.
$a_{manufacturing}$	=	Initial quality flaw size attributable to the manufacturing process.
$a_{net\ section\ yield}$	=	Crack size at onset of rapid propagation due to net section yield.
FAA	=	Federal Aviation Administration
FR	=	Per flight failure rate based on the joint probability of having a crack $a \geq a_{inst}$ and encountering 100% limit load.
MED	=	Multiple Element Fatigue Damage
MSD	=	Multiple Site Fatigue Damage
N^{TH}	=	Fatigue life threshold based on a given failure rate.
N_{ainst}	=	Mean life for a crack to grow to a_{inst} (includes crack initiation life)
NDI	=	Nondestructive inspection (includes visual)
$p(N^{TH})$	=	Probability of having a crack $a \geq a_{inst}$ during the N^{TH} th flight
$p(N^{TH}+1)$	=	Probability of having a crack $a \geq a_{inst}$ during the $N^{TH} + 1$ flight
SID	=	Supplemental Inspection Document
s	=	Standard deviation of (log N) normal distribution

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(1) DOT-TSC-FA890-88-26, 'Proceedings of THE INTER-NATIONAL CONFERENCE ON AGING AIRPLANES', Appendix B, August 1988

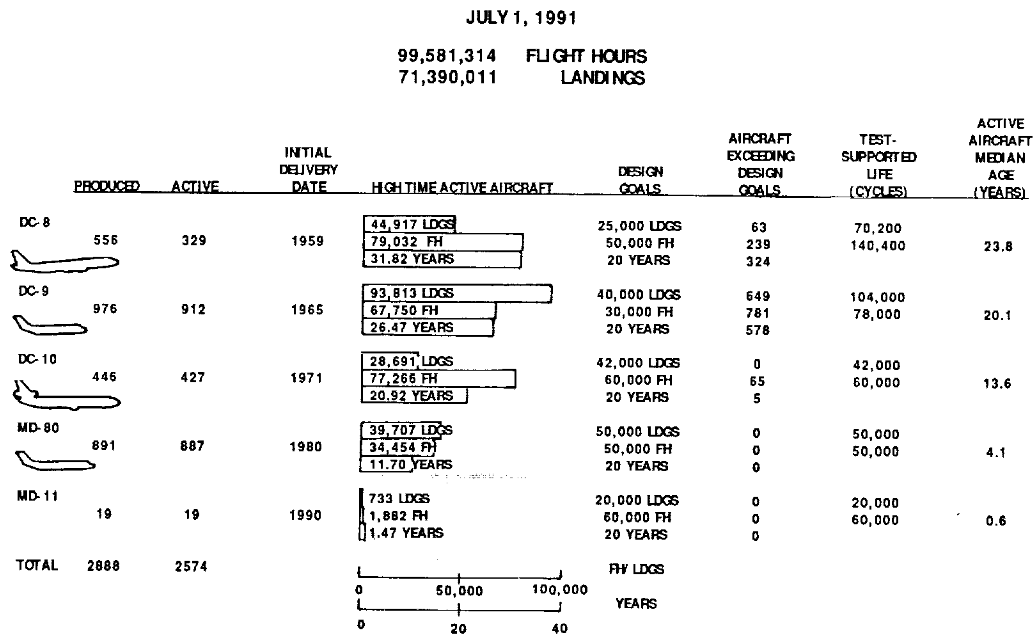


Figure 1 Douglas fleet statistics - July 1, 1991

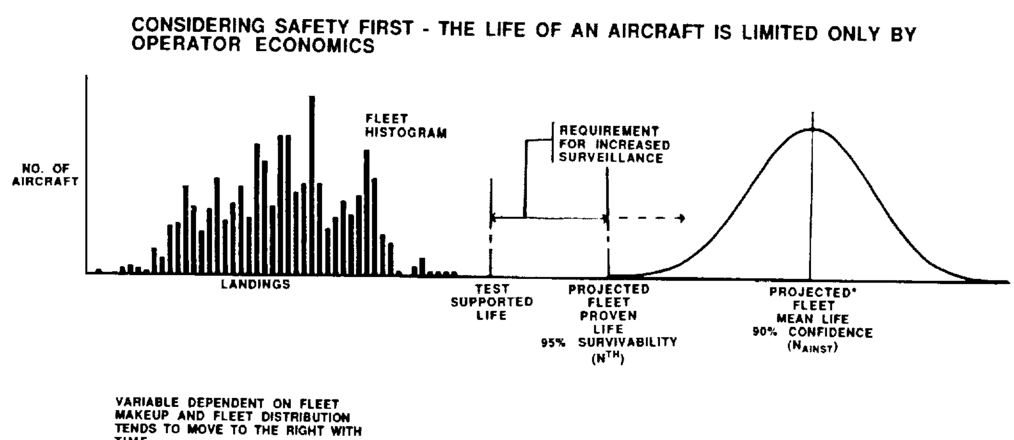


Figure 2 Fleet projected/proven life

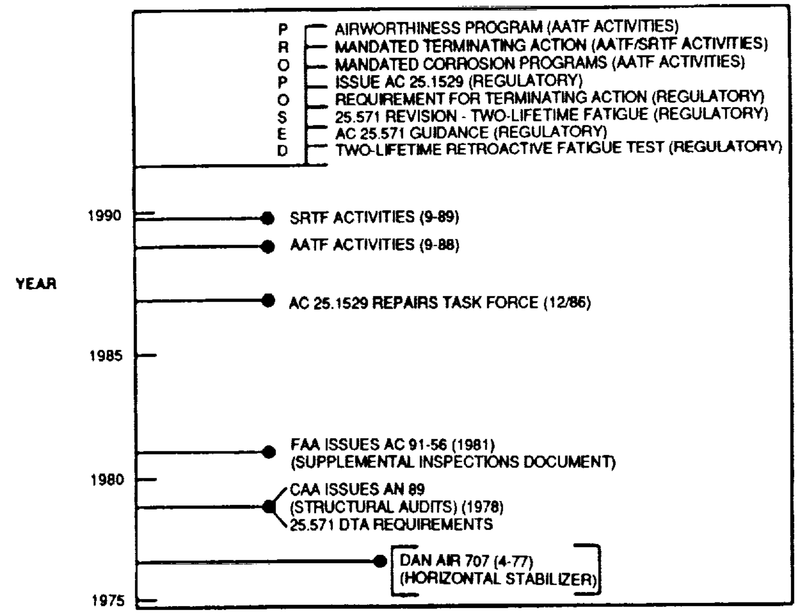
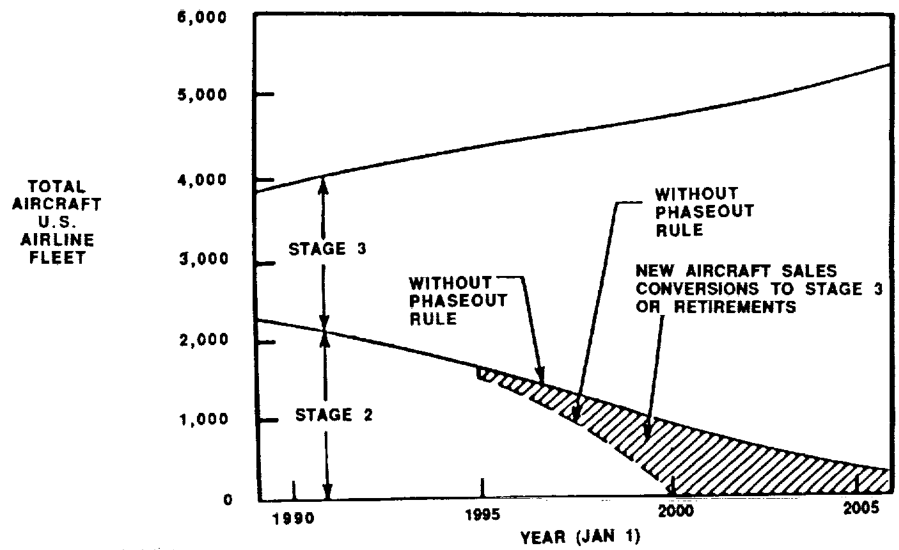


Figure 3 Airframe regulatory issues



MAY EFFECT NUMBER OF OLDER AIRCRAFT

Figure 4 Stage 3 noise - proposed requirements

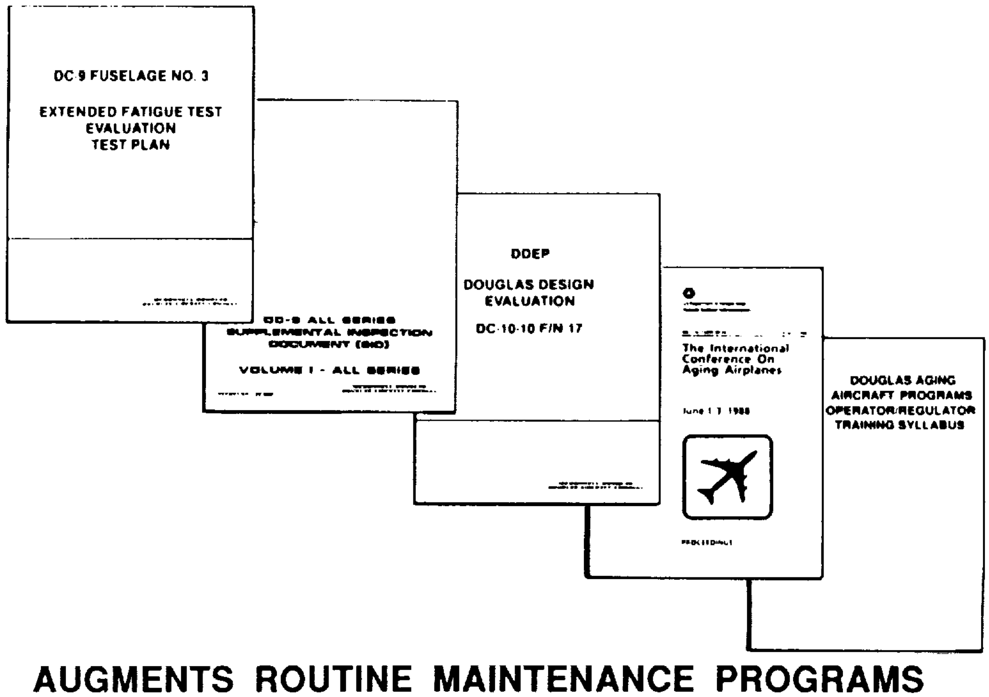


Figure 5 DAC aging aircraft programs

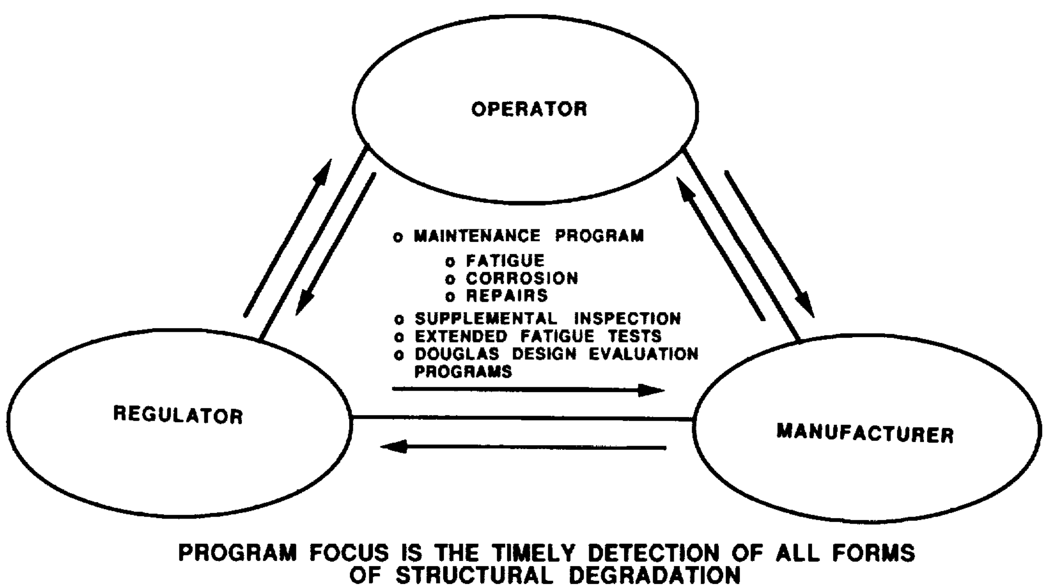


Figure 6 Maintaining the safety of the aging fleet

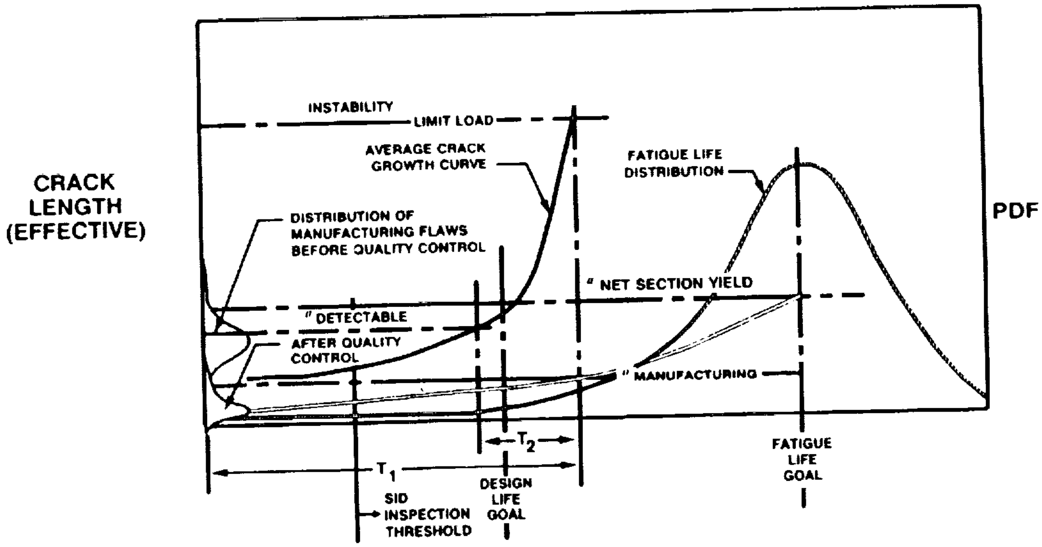


Figure 7 A structural life concept

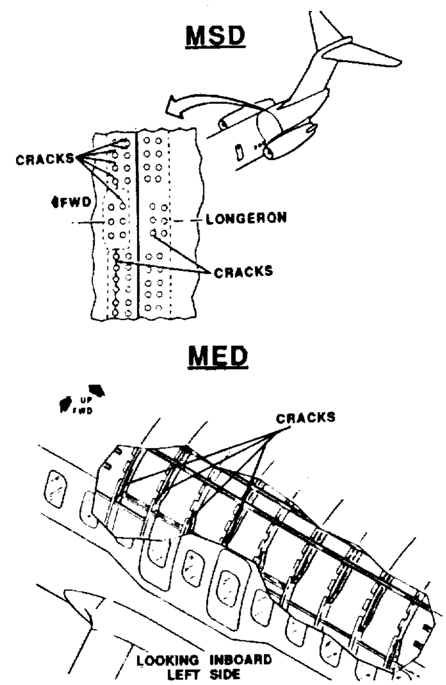
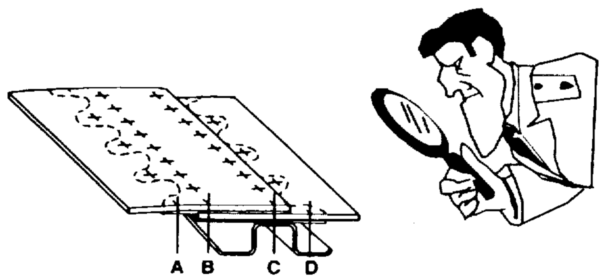


Figure 8 Multiple site and multiple element fatigue damage

- o INITIAL MAINTENANCE PROGRAM BASED ON VISUAL INSPECTION

SPLICE INSPECTIBILITY



PREDOMINANT CRACKING WILL OCCUR IN ROW B
ON THE OUTSIDE SKIN

- o MSD AND MED MAY NOT BE VISUALLY DETECTABLE

THEREFORE, COMPETENT PROGRAM MUST BE IN PLACE

Figure 9 Maintenance program issues

1. DETERMINE AREAS POTENTIALLY SUSCEPTIBLE TO MSD.
2. DETERMINE AREAS OF POSSIBLE CONCERN FOR MED.
3. ASSESS EACH SUSPECT AREA'S LEVEL OF SAFETY WITH CURRENT AND AUGMENTED MAINTENANCE PROGRAMS.
4. SELECT AREAS REQUIRING ADDITIONAL MONITORING TO ESTABLISH THE REQUIRED LEVEL OF SAFETY.
5. DETERMINE ADDITIONAL AREA SPECIFIC ACTIONS TO ACHIEVE THE REQUIRED LEVEL OF SAFETY.
6. IMPLEMENT APPROPRIATE ACTIONS.

Figure 10 Model specific audit for MSD/MED

A. SELECTED LIMITED NON-DESTRUCTIVE DISASSEMBLY, INSPECTION AND REFURBISHMENT OF HIGH TIME AIRPLANES CONTINUING IN SERVICE.

B. CONTINUING ASSESSMENT OF THE FLEET DEMONSTRATED CAPABILITY THROUGH DILIGENT MONITORING OF SERVICE EXPERIENCE.

C. FLEET EXPLORATION OF HIGH TIME AIRPLANES WITH IMPROVED STATE OF THE ART NDI TECHNIQUES.

D. TESTING OF NEW OR USED STRUCTURE ON A SMALLER SCALE THAN FULL COMPONENT TESTS (I.E. SUB-COMPONENT AND/OR PANEL TESTS).

E. FATIGUE TEST OF HIGH TIME AIRPLANE OR FULL SCALE MAJOR COMPONENT FOLLOWED BY DETAILED TEARDOWN OF TEST ARTICLE.

F. TEARDOWN OF HIGH TIME AIRPLANE.

Figure 11 Model specific candidate actions

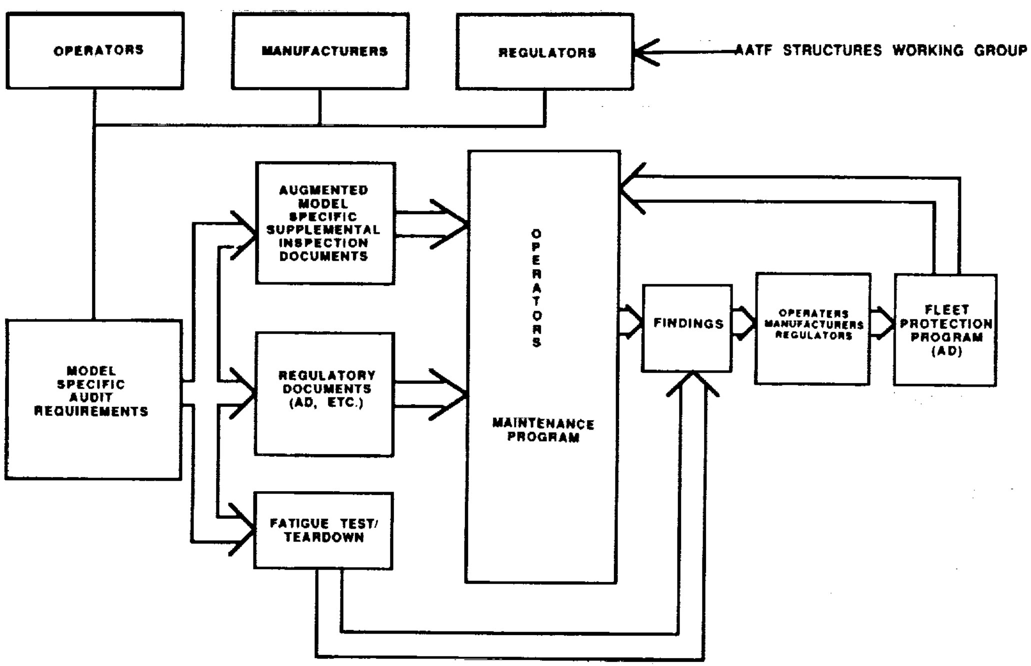


Figure 12 Monitoring of fleet findings

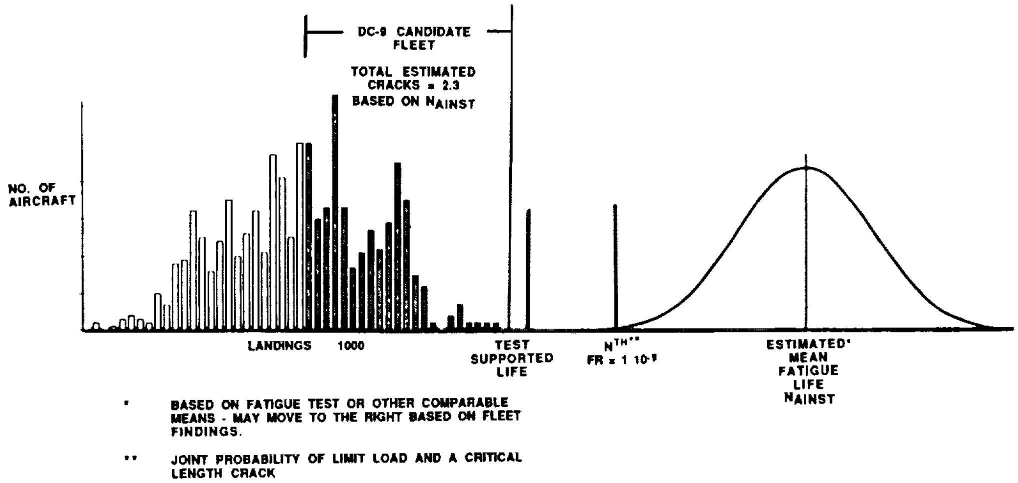


Figure 13 Maintaining the desired level of safety