UNITED STATES DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

FAA AGING TRANSPORT NON-STRUCTURAL SYSTEMS PLAN

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INTRODUCTION

The Federal Aviation Administration (FAA) Aging Non-Structural Systems Plan describes various maintenance, training and reporting initiatives, development of advisory material, research programs, and other activities that have already started or will be undertaken by the FAA in order to address the White House Commission on Aviation Safety and Security (WHCSS) recommendations regarding aging non-structural systems. This recommendation states: ***In cooperation with airlines and manufacturers, the FAA's Aging Aircraft program should be expanded to cover non-structural systems.*** Throughout this report the words "aging non-structural systems" and "aging systems" will be used interchangeably.

The Commission was concerned that existing procedures, directives, quality assurance, and inspections may not be sufficient to prevent safety related problems caused by the corrosive and deteriorating effects of non-structural components of commercial aircraft as they age.

As part of its recommendations, the Commission recommended that the FAA work with airlines and manufacturers to expand the aging aircraft program to include non-structural components, through steps including: full and complete tear-downs of selected aircraft scheduled to go out of service; the establishment of a lead-the-fleet research program; an expansion of the FAA-DOD-NASA cooperative aging aircraft program; an expansion of programs of the Airworthiness Assurance Working Group to include non-structural components; and encouraging the development of modern technical means to ensure and predict the continued airworthiness of aging non-structural components and systems. The FAA plan outlined below addresses the commission's recommendations and provides brief details and milestones that will be tracked by the FAA Aging Transport Systems Oversight Committee.

Aging systems on the airplane are addressed through the FAA's continuing airworthiness program. Under this concept, the airplanes are continuously inspected and repairs made at various intervals to ensure that they remain in an "airworthy" or safe condition. In addition to maintenance to preclude safety related failures, maintenance is done to ensure that an acceptable level of reliability is maintained between maintenance intervals. As an airplane ages, it becomes increasingly expensive to keep it in an airworthy condition with high reliability. The maintenance costs associated with meeting acceptable safety and reliability standards, such as "on-time performance" (arrival at a destination within 15 minutes of schedule) and completion of a schedule flights, become so great that the airplane is removed from service.

As the airplane ages, operational experience and deteriorating effects caused by age change the inspection, repair, and replacement intervals for the airplane's components. Systems are continuously being repaired and overhauled. Wire is replaced as deterioration occurs. Landing gear are removed and replaced by reconditioned units at a regular interval. Many system elements do not stay on the airplane for it's entire life. Reliability programs are used by the airlines to adjust maintenance schedules for inspection and replacement of parts. Intervals are set for acceptable performance. Trends are monitored and maintenance intervals and repairs are adjusted to keep the airplane airworthy and reliable. This system has been very effective in ensuring that our aging fleet of airplanes remains airworthy.

In order to fully address the WHCSS recommendations on aging systems, an Aging Non-Structural Systems Study team was formed. This team, led by the Transport Airplane Directorate (TAD), consisted of both Aircraft Certification and Flight Standards personnel. Systems engineers from both the Los Angeles and Seattle Aircraft Certification Offices were accompanied by representatives from the Flight Standards Service, including the Washington Aging Airplane Program Office and the Transport Aircraft Evaluation Group. The Boeing Company provided the FAA team with five engineers who had detailed knowledge of the airplane systems to assist with the on-site airplane evaluations.

The Aging Non-Structural Systems team developed several initiatives to re-examine the FAA approach to aging systems and to ascertain the scope of any problem. Three on-site visits to maintenance facilities were accomplished. Three DC-10s, a DC-9 and a Boeing 727, representative of the "aging" fleet of transport airplanes, were evaluated. These three airplane models were chosen for evaluation based primarily on their availability, age in terms of years of service, hours of operation, number of cycles (landings), and, level of inspections and maintenance being performed. The DC-10's were all over 24 years old and had in excess of 24,000 cycles. The DC-9 was 29 years old and had approximately 70,000 cycles. Finally, the Boeing 727 was 19 years old and had approximately 21,000 cycles. Evaluation of these airplanes was primarily based on visual inspections. Airplane wiring, lightning protection, hydraulics and flight control systems received special emphasis.

All these airplanes were undergoing a "heavy maintenance visit" (HMV). During an HMV, the airplane undergoes extensive inspection and maintenance. This requires that the airplane be out of service approximately two to five weeks depending on the age and number of maintenance items to be completed. This level of inspection and maintenance is typically performed every three to five years. Most of the airplane's major systems are available for viewing. Skin panels, outer body fairings, seats, galleys and floor panels are removed.

In addition to the on-site evaluations, a two day meeting with a group of FAA Principal Maintenance Inspectors (PMI) who are tasked with oversight of major air carriers was conducted in order to discuss their aging systems concerns. Also, two meetings were conducted with Boeing, the manufacturer of many of today's aging passenger airplanes. Finally TAD initiated a study using various accident/incident data bases relevant to aging transport airplanes to ascertain aging non-structural system trends. Emphasis was on the older jet-powered transport airplanes which are still in service but are approaching or have exceeded their design life goal, typically twenty years.

The FAA has also initiated a specific investigation into fuel tank wiring in addition to work completed by the aging systems team. Because of safety related problems found in the fuel tank conduit wiring, airworthiness directives have been issues on certain B737 airplane models. Other transport airplanes with similar fuel tank designs are currently being examined.

FINDINGS

Based on on-site evaluations of three airplane models, meetings with FAA Principal Maintenance Inspectors (PMIs) and Boeing, and an analysis of aging systems using the FAA's National Aviation Safety Data Analysis Center (NASDAC) aviation safety databases, a plan has been formulated to address our aging transport airplane systems. The plan supports the recommendations made by the WHCSS and acknowledges that a more extensive examination of "aging" airplane systems is needed. More aging airplane models need to be evaluated and the wire analyzed in the laboratory to fully characterize the condition of the wire on our aging transport airplane fleet. Initiatives to improve maintenance training, inspections, and practices are incorporated into the plan. Also addressed are specific safety initiatives related to aging wire found in fuel tank conduits.

On-site inspections of three representative aging transport airplane models shows some deterioration of wiring components, namely, wire, wire bundles, connectors, grounds, clamps and shielding. As wire ages it becomes stiff and easily cracked if improperly handled or allowed to move unrestrained. Wire bundles are difficult to inspect in many areas. Contamination of wire bundles with metal shavings during maintenance is a common occurrence. In some areas, contamination of wire bundles with excessive dust and various fluids was noted. Isolated cracking of outer layers of multi-layer insulation can be seen in some wire types. Ground terminal were found with resistance measurements outside manufacturers specifications. Connectors are not normally disassembled during inspections, but where these could be observed, isolated incidences of corrosion on pins was observed.

Current maintenance practices do not adequately address wiring components (wire, wire bundles, connectors, clamps, grounds, shielding). Inspection criteria is too general. Typically a zonal inspection task card for wiring would state, "Perform a general visual inspection". Important details pertaining to unacceptable conditions are lacking. Airlines report shortcomings in the manufacturer's maintenance and repair manual on wire, Chapter 20. The current presentation and arrangement of standard practices make it difficult for an aircraft maintenance technician to locate and extract the pertinent and applicable data necessary to effect satisfactory repairs. Wire replacement criteria may not be adequate. Under current maintenance philosophy, wire in conduits is not inspected. On-site inspections and reporting from operators indicate many examples of improper installation and repair of wiring. A review of incident reports and maintenance records indicate current reporting system lacks visibility for wiring making it difficult to assess aging trends. There are no maintenance codes to identify wire failures.

In addition, there is currently no systematic process to identify and address potential catastrophic failures caused by electrical faults of wiring systems, aside from accident investigation associated activities. A process similar to the MSG-3 review process, which is used for mechanical and electrical components, is recommended to find and address potential catastrophic events associated with wiring system faults.

The class of airplanes evaluated during the study use primarily mechanical or hydraulic flight control systems. Although newer, the class of airplanes introduced in the early 1980s incorporating full authority electronic flight and engine controls have now been in service over fifteen years. The impact of aging on these flight-critical electronic control systems, their wiring, and their lightning and High Intensity Radiated Fields (HIRF) protection is also addressed in the aging airplane system plan. Additional evaluations should be performed to determine the scope of aging issues associated with these airplanes and their systems.

In the mechanical systems area, isolated observations of corrosion on flight control actuators, associated linkage, and hydraulic fittings were noted. Some flight control actuators contain uninspectable shafts. The aging non-structural systems plan calls for additional testing and better inspection criteria to address these observations.

The most current information was used in the development of the tasks and schedules contained in this plan. However, due to the complex nature of the tasks and the interrelationships between tasks, the plan may need to be revised periodically to reflect a change in scope or schedule.

This report contains six appendices:

(1) Appendix I: Summaries of On-Site Evaluations of "Aged" DC-10, DC-9, B727.

(2) Appendix II: Summaries of Principal Maintenance Inspector Workshop.

(3) Appendix III: Meeting minutes, Boeing.

(4) Appendix IV: NASDAC Study.

(5) Appendix V: Glossary of Acronyms.

(6) Appendix VI: Major Contributors to the FAA Aging Non-Structural Systems Plan.

AGING TRANSPORT NON-STRUCTURAL SYSTEMS PLAN

<u>Task 1</u>. Establish an Aging Transport Systems Oversight Committee to coordinate the various aging systems initiatives within the FAA.

<u>PLAN DETAILS, TASK 1</u>:

The FAA Aging Systems Oversight Committee members will be drawn from across the FAA, including representatives from the Flight Standards Service and the Aircraft Certification Service. The Committee will encourage continuing focus on aging systems and manage the Aging Transport Non-Structural Systems Plan tasks to ensure that they are proceeding on schedule and are achieving the desired results.

The committee will encourage a pro-active continuing focus on aging non-structural systems with industry by:

- initiating research projects to address aging systems issues
- participating in industry fleet reviews of selected systems
- sponsoring periodic FAA/DOD/NASA technical exchanges on topics relevant to aging systems (polyimide wire, "hot stamping," best inspection practices, etc.)
- identifying training needs for FAA engineers and Flight Standards Inspectors in wiring practices
- conducting a yearly Principal Maintenance Inspector workshop with Transport Directorate engineers to address continuing airworthiness issues
- working with industry to develop a better reporting system which would allow more visibility to incidents and maintenance actions which have an aging system root cause or component
- participating in the yearly FAA/NASA/DOD sponsored Aging Airplane Conference

Responsible Party: FAA Aging Systems Oversight Committee

Schedule:

- September 1998: establish committee
- Semiannual review of the FAA Aging Systems Plan to determine progress on accomplishing the plan and to identify areas where the plan should be revised.

Task 2. Conduct an in-depth review of the aging transport fleet and make model-specific safety recommendations related to airplane systems.

Task an Aviation Advisory Committee (AAC) to accomplish the following:

A. Conduct transport airplane evaluations.

Based on preliminary findings from the three aging airplane model on-site evaluations, the FAA has identified a need to make a comprehensive evaluation of the state of the aging transport fleet including the identification of model-specific problems which need to be addressed.

PLAN DETAILS, TASK 2.A.:

The advisory committee shall accomplish the following:

- establish the airplane models to be evaluated

In addition to the older designs currently operating in the fleet, i.e. 727, A300, newer airplanes introduced in the early 1980s incorporating full authority electronic flight and engine controls need to be included. The impact of aging on these flight-critical electronic control systems, their wiring, and their lightning and HIRF protection needs to be assessed. Airplane models that introduced flight-critical electronic systems, such as the early Boeing 757 and A320 have ten to fifteen years in service.

- establish criteria for evaluation

- submit a plan for FAA approval within 6 months of tasking. The plan will include evaluation of airplanes currently in service as well as airplanes which have been retired from service. Also a review of DOD/NASA “lessons learned” pertaining to airplane maintenance practices must be addressed.

- complete evaluations and submit findings and recommendations to FAA within 18 months of tasking

Responsible Parties: Aircraft Certification Service (ANM-100), AAC

Schedule:

- November 1998: Publish tasking in Federal Register
- June 1999: Approval of Evaluation Plan
- June 2000: Review findings and take corrective action

B. Review service history, service bulletins and service letters for the aging transport fleet which pertain to aging systems for possible mandatory action.

Under the Aging Aircraft Program, one of the tasks developed involved reviewing service history, service bulletins and service letters to determine if previously defined improvements to the aircraft should be made mandatory to preclude the occurrence of unsafe conditions as the aircraft aged. To parallel the success of that initiative, a similar review of the service history, service bulletins and service letters pertaining to aging systems will be conducted.

PLAN DETAILS, TASK 2.B.:

AAC shall accomplish the following:

- establish criteria for mandatory action
- establish model specific-task groups
- submit recommendations for mandatory action

Responsible party: Aircraft Certification Service (ANM-100), AAC

Schedule:

- November 1998: Publish tasking in Federal Register
- May 1999: Review recommendations and take corrective action

Task 3. Enhance airplane maintenance to better address aging airplane systems.

Task AAC to accomplish the following:

A. Improve inspection criteria for wiring

PLAN DETAILS, TASK 3.A.:

Currently, wiring condition is assessed by a "general visual inspection." Wiring does not get the same level of attention in zonal inspections as hydraulics lines and fittings. A more complete description of undesirable wiring system conditions is needed. Observations of chaffing, broken clamps, sagging, interference, contamination, cracking, and splitting of wire need to be addressed. The inspection criteria needs revision to guide inspectors in their zonal evaluations.

Responsible parties: Flight Standards Service, AAC

Schedule:

- September 1999: Develop and publish inspection guidance

B. Define acceptance criteria for corrosion on flight control actuators, associated linkages and for hydraulic fittings.

PLAN DETAILS, TASK 3.B.:

During the on-site evaluations, corrosion was found on various flight control linkages and actuators as well as on hydraulic line "B" nuts and fittings. Currently an acceptance criteria for these items does not exist. Corrective actions for unacceptable levels of corrosion should also be provided.

Responsible parties: Flight Standards Service, AAC

Schedule:

- October 1999: Publish acceptance criteria/corrective actions for corrosion

C. Revise Maintenance Steering Group (MSG)-3 process to address catastrophic events associated with wire failures as MSG-3 review items. Identify maintenance tasks and inspection intervals for wire failures with catastrophic consequences.

PLAN DETAILS, TASK 3.C.:

Wire in conduits is not easily inspectable under the current zonal inspection concept. Further, there are many areas in the airplane where it is difficult to see and fully inspect wire bundles. A MSG-3 like process review will be conducted to examine the potential of wire bundle failures to cause potential catastrophic effects like fire or loss of control. An expected result of this review would be the incorporation of periodic inspections or other actions into the maintenance programs to detect potentially catastrophic electrical faults.

Responsible parties: Flight Standards Service, AAC

Schedule:

- April 2000: Completion of analysis
- July 2000: Update maintenance requirements

D. Establish a means to minimize contamination of wiring from metal shavings.

PLAN DETAILS, TASK 3.D.:

During the on-site visits to observe maintenance associated with aging airplanes, considerable metal shaving contamination of wire bundles throughout the airplane was evident. The shavings result from drilling of structures during maintenance activities. The current practice is to minimize this contamination and to vacuum up the shavings after completion of the maintenance work. However, this procedure still leaves some contamination, and it is clear that greater care to prevent contamination is needed. Over time, these shavings left in the airplane can cause shorting of wires in bundles and failure of electrical systems on the airplane. It is not known if this practice has resulted in any serious airplane accidents or incidents.

This practice, if not changed, may become a serious aging airplane problem for new airplanes where .008 inch insulation thickness wire is commonplace. The aging airplanes that were examined during the on-site visits had insulation thickness of about .020 inches so the “aged” airplane wire is much more “robust” to this type of insult.

Responsible parties: Flight Standards Service, AAC

Schedule:

- September 1999: Distribute guidance material

E. Review air carrier and repair station inspection and repair training programs to ensure that they adequately address aging wiring system components (wire, connectors, brackets, shielding, clamps, grounds).

PLAN DETAILS, TASK 3.E.:

As wire ages it becomes stiff and is subject to premature cracking from improper handling. In addition, bundles can sag and chaffing with airplane structure can result. Where cracking occurs, repairs are made using wire splices. Boeing has noted an increasing incidence of failures of wire due to improper splicing of wire. Chapter 20 of the airplanes maintenance document outlines wear limits for repair and repair methods. Maintenance personnel need to be thoroughly familiar the recommendations specified in Chapter 20.

Wire is subject to more rapid deterioration with age in areas of high fluid contamination, vibration, temperature variation, and where it is attached to parts that are moved or removed often. Such areas might be where attached to doors, control column stick shakers, window heaters, or equipment with a high removal rate. Wheel wells, wing leading and trailing edges, and areas beneath galleys and lavatories are especially harsh environments for wire, wire grounds, and connectors. Excessive dust contamination of wire bundles can be a safety concern as it creates a fuel source in the presence of arcing caused by a shorting wire.

Inspectors need to understand aging effects in wiring system components and how they affect safety. They must be able to recognize deteriorating conditions such as chaffing, interference, corrosion, cracking and clamping deficiencies and identify these areas for maintenance action. In addition, inspecting wire can be a tedious task requiring inspection in very confined quarters. Human factors such as fatigue and complacency are important considerations in an inspector training program.

Responsible parties: Flight Standards Service, AAC

Schedule:

- August 1999: Develop criteria for AAC review of inspection and repair training programs
- December 1999: Publish guidance material

F. Develop guidance material to address electromagnetic compatibility, lightning, and HIRF protection features in the maintenance programs.

Typical aircraft maintenance programs do not explicitly address features that significantly affect lightning and High Intensity Radiated Fields (HIRF) protection. Also, the typical inspections rely on visual observations of corrosion or wear of these features, yet the visual observations do not provide direct indication of the lightning or HIRF protection effectiveness. Guidance is needed to identify effective maintenance activities for HIRF and lightning protection, so that these activities can be incorporated into the instructions for continued airworthiness, and subsequently into the aircraft maintenance programs. The guidance should identify appropriate visual inspection and more detailed inspection methods, including functional tests, and the appropriate applications for these methods.

PLAN DETAILS, TASK 3.F.:

Responsible party: Flight Standards Service, Aircraft Certification Service, AAC.

Schedule:

- September 1999: Identify current HIRF and lightning protection maintenance approaches.
- May 2000: Identify revised HIRF and lightning protection maintenance methods.
- August 2000: Publish guidance material.

G. Review and update Chapter 20, "Standard Practices for Wiring"

PLAN DETAILS, TASK 3.G.:

- The current manufacturer's (Boeing, Airbus) Chapter "20" contains a myriad of data and procedures regarding every conceivable wiring type and terminating device located throughout the aircraft and required for integration of all systems/all components.

- Data from each vendor (Amphenol; Burndy; ITT, for example) is included in a standard ATA Spec 100 format, i.e., general, equipment & materials, buildup, removal and replacement etc. However, the large variety of vendor data presented can add to a maintenance technician's confusion when determining the applicable standard practice.

- The current presentation and arrangement of these standard practices make it difficult for an aircraft maintenance technician to locate and extract the pertinent and applicable data necessary to effect satisfactory repairs.

- All replacement wire or electrical hardware specified in Chapter 20 will likely not be available in airline inventory and suitable replacement substitutes must be used.

- Aircraft alterations such as the installation of modern digital flight: environment, data, communications and navigation equipment after production will likely not be addressed in the existing Chapter 20.

It is recommended that each airline/operator should work with the OEM, ATA and vendors to revise and create a practical, user friendly "standard practices" chapter of the aircraft maintenance manual. Operators should be encouraged to create specialized training curriculums to address conventional and peculiar types of aircraft wiring techniques and practices. Operators should be encouraged to create and publish supplements to chapter 20 to incorporate any "standard repairs" devised by company engineering and necessary due to deterioration peculiar to the operator's environment. This supplement can contain references to preferred wiring types, by CPN (company part number) that are commonly stocked throughout an operator's logistics inventory.

Responsible parties: Flight Standards Service, AAC

Schedule:

- September 1999: Establish preliminary set of requirements
- December 1999: Publish first update to guidance material.

<u>Task 4</u>. Add aging systems tasks to the aging airplane research program

The FAA will prepare Research Project Descriptions to initiate the process to obtain funding for the following research needs.

A. Determine if a service life for airplane wire is appropriate. Then, if appropriate, establish the service life of all types of airplane wire used in transport airplanes

<u>PLAN DETAILS, TASK 4.A.</u>:

Based solely on visual inspections, the integrity of aging airplane wire appears adequate. However, some isolated deterioration was noted in the outermost insulation layers in all three airplane models examined. Research is needed to determine if a service life for wire is appropriate and needed.

Responsible Party: Aircraft Certification Service.

Schedule:

- September 1998: Provide the Standards Management Team with prioritized research needs.

B. Establish condition of aging system wiring components and validate the adequacy of visual inspections

<u>PLAN DETAILS, TASK 4.B.</u>:

To validate the visual condition of aging wiring system components (connectors, circuit breakers, wires and wire bundles), samples of airplane wiring system components will be collected and analyzed in the laboratory to determine if they meet appropriate performance standards. Laboratory analysis of aged wire will establish if problems, not evident by the visual inspection, are evident in the various wire insulation layers.

Responsible Party: Aircraft Certification Service.

Schedule:

- September 1998: Provide the Standards Management Team with prioritized research needs.

C. Development of Non-Destructive Test (NDT) tools for inspection of wiring systems

PLAN DETAILS, TASK 4.C.:

Under current maintenance inspection practices, wire is inspected visually. Inspection of individual wires in bundles and connectors is not practical because aged wire is stiff and dismantling of bundles and connectors may introduce safety hazards. Wire is difficult to inspect in several areas of the airplane due to inaccessibility. Wiring inside conduits is not inspectable by visual means. These difficulties, associated with the inspection of aging wiring bundles and connectors, can be overcome by the development and use of NDT tools to assess the state of the wiring in an airplane. The FAA will explore what tools already exist for these purposes. Where tools do not exist, promising technologies will be explored for adoption to the problems associated with inspection of aging wiring systems.

Responsible Party: Aircraft Certification Service.

Schedule:

- September 1998: Submit prioritized research needs

D. Establish aging effects on Aircraft Lightning and HIRF protection systems

The recent AD on the Boeing 777 for connector corrosion, which affected the flight control system lightning and HIRF protection, and similar reports of corrosion on A-320 connectors, point out the need to understand the issue of aging aircraft lightning and HIRF protection. Currently, the aging effects are not well known, and the type certification and continued airworthiness requirements to assure continued protection are vague. Research is required to develop a better understanding of the scope and depth of the issue, ultimately leading to appropriate certification and maintenance requirements.

PLAN DETAILS, TASK 4.D.:

Responsible Party: Aircraft Certification Service.

Schedule:

August 1998: Identify five year research plan
September 1999: Determine scope of aging HIRF and lightning protection issues
September 2000: Complete research report on scope of aging HIRF and lightning protection issues with refined plan for subsequent research

E. Develop arc fault circuit breaker

Present commercial airplane circuit breakers do not detect and react to arcing faults associated with the chaffing and subsequent intermittent arcing when bare wires contact metal airplane structure or other bare conductors. The Navy is funding a research program to address this aging wiring fault problem. The FAA should support the Navy's Arc Fault Circuit Protection (AFCP) Program by added additional funding to this development program.

PLAN DETAILS, TASK 4.E.:

Responsible Party: Aircraft Certification Service; Naval Weapons Center, Electrical Power Systems Division.

Schedule:

March 1999: Award contract
April 2001: Delivery of Arc Fault Circuit Breaker for flight testing
December 2001: Recommendations to Industry

F. Destructive testing of flight control linkages.

PLAN DETAILS, TASK 4.F.:

Some flight control linkages rely on secondary load paths for strength which are uninspectable. Testing is necessary to verify the continued ability of the secondary load paths to sustain loads in the presence of primary load path failures after the airplane has exceeded its design life.

Responsible Party: Aircraft Certification Service

Schedule:

- August 1999: Issue any recommendations for maintenance

<u>Task 5</u>. Improve reporting of accident/incident and maintenance actions involving wiring system components (wire, connectors, wire shields, grounds, circuit breakers).

A. The FAA will urge the Airline Transport Association (ATA) to establish codes to better identify wiring system component failures and maintenance actions

<u>PLAN DETAILS, TASK 5.A.</u>:

ATA codes are used by maintenance personnel to identify the particular system which has failed. There is no code to identify wiring component failures so visibility to wiring system failures is lacking. This makes trend analysis difficult. The military has an extensive wire system fault identification system which should be examined for applicability to the commercial airline industry. The FAA will urge the ATA to develop codes to better identify wiring system component failures and maintenance actions.

Responsible Party: Flight Standard Service, ATA

Schedule Goal:

- July 1999: Issue new codes for wire system components.
- December 1999: Complete maintenance personnel training on new codes

B. Improve reporting formats of incident/accidents and maintenance data to make the integration and analysis of data bases more efficient for assessing aging trends and problems.

<u>PLAN DETAILS, TASK 5.B</u>:

Using the current reporting system, it is often a difficult and time consuming process to find the real cause of problems. To address this problem, the FAA has issued a Notice of Proposed Ruling Making which proposes to revise the reporting requirements for air carrier certificate holders and certificated domestic and foreign repair stations concerning failures, malfunctions, and defects of aircraft, aircraft engines, systems and components. The proposed rule would clarify and standardize the type of information submitted to the FAA allowing the FAA to identify trends that may affect aviation safety. The objective of the proposed rule is to update and improve the reporting system to effectively collect and disseminate clear and concise information, particularly with regard to aging aircraft, to the aviation industry.

Airlines currently expend a large amount of time and effort in reporting findings during various checks. However, it seems that the supplied data is not able to be utilized as fully as desired. In addition much of the data is recorded on paper only, so computer analysis to establish trends is difficult. Several data bases exist and reporting of service difficulties is not well integrated between FAA, operators, and manufacturers. Through the NASDAC Data Management Working Subgroup of the FAA task force on aviation safety data standardization, formed to address WHCSS recommendation 1.8.3 on developing standard safety data bases, the FAA will re-examine our reporting formats to make them more efficient for analysis and ensure that they meet aging system reporting needs.

Responsible Party: Aircraft Certification Service, Office of System Safety, NASA, NTSB

Schedule:

- December 1998: Identify a Transport Directorate representative to the NASDAC Data Management Working Group.
- September 1999: Publish recommendations for reporting format improvements.

C. Add additional data to the National Aviation Safety Data Analysis Center (NASDAC) databases to better address aging systems.

<u>PLAN DETAILS, TASK 5.C.</u>:

As part of the review of aging systems problems, a study was conducted using the NASDAC databases. NASDAC is a FAA facility which provides access to a number of aviation safety databases with on-line data analysis capability. The purpose of the study was to determine if there was a trend in certain system failures as the airplane ages. This information would help to identify emerging system safety problems. Several difficulties were encountered in the use of the databases. It was difficult to establish age related trends due to a lack of normalizing factors such as airplanes in fleet, departures or average age. The databases lack data prior to 1982 important in analyzing "aging" models built in the 1960's. Data was difficult to convert to spread sheet format for analysis. Service Difficulty Reports (SDRs) cannot be sorted by airplane type (general aviation, air carrier).

Responsible Party: Aircraft Certification Service, Office of System Safety

Schedule:

October 1999: Update data bases to include cycles, airplane age, and data prior to 1982.

D. Recommend that aging airplane components like wiring, circuit breakers, connectors, pumps, motors, harnesses removed from airplane during maintenance, be examined by airline or repair station facilities for safety implication of failure.

PLAN DETAILS, TASK 5.D.:

Examination of removed system component can improve safety by early identification of aging systems problems and trends. The FAA will recommend that a system be put in place at each operator's maintenance facility to examine parts removed from airplanes for safety implications of failure.

Responsible parties: Aircraft Certification Service, airline operators

Schedule:

October 1998: Notification to operators of recommendations regarding parts disposition.

Task 6. Evaluate the need for additional maintenance of transport airplane fuel system wiring and address any unsafe conditions.

A. Review the large transport airplane fleet service problems to identify any unsafe conditions with respect to fuel system wiring. Provide corrective actions where necessary.

PLAN DETAILS, TASK 6.A.: The FAA has asked the manufacturers of older large transport airplanes that have internal fuel tank high power circuitry to inspect high service time airplanes and report on the condition of the wires and electrical conduit. Any unsafe conditions will be address by mandatory corrective action.

Responsible Parties: Aircraft Certification Service, operators, OEMs

Schedule:

- November 1998: Complete initial review.

B. Develop a Special Federal Aviation Regulation (SFAR) that addresses fuel system wiring design and maintenance practices.

PLAN DETAILS, TASK 6.B.: The FAA is drafting an SFAR that addresses fuel system wiring design and maintenance practices regarding transport airplanes. The SFAR will require certain airplane manufacturers to substantiate to the FAA that the fuel system design precludes ignition sources. The manufacturer must conduct a design review to determine what additional maintenance steps are required to maintain the integrity of airplane fuel tank wiring.

Responsible Parties: Aircraft Certification Service, Flight Standards Service, OEMs

Schedule:

- September 30, 1998: Forward Draft SFAR to OST/OMB
- The SFAR (NPRM) will be issued following OST/OMB review

<u>Task 7</u>. Improve wiring installation drawings and instructions for continuing airworthiness.

While not directly an aging issue, findings from our on-site visits indicate that improvements are needed in the FAA's wiring installation drawing approval process to ensure that the installation details of "post-delivery" airplane modifications are consistent with the original manufacturer's wire installation guidelines and accepted industry practices. During one of our on site visits, several areas of wire installation deficiencies were noted. Also improvements to the maintenance inspection and repair instructions are necessary so adequate maintenance can be performed on wiring components (wire, bundles, connectors, grounds, clamping) of new systems added after the airplane's original manufacturing date.

A. Task the Society of Automotive Engineers (SAE) to write an Aviation Recommended Practice (ARP) to define best practices for modification of existing wiring on transport airplanes.

<u>PLAN DETAILS, TASK 7.A.:</u>

Responsible party: Aircraft Certification Service, SAE

Schedule:

- October 2000: Establish requirements
- October 2001: Publish ARP

B. Develop training aids in wiring installation practices for certification engineers and designees.

<u>PLAN DETAILS, TASK 7.B.:</u>

Responsible party: Airplane Certification Service

Schedule:

- March 1999: Establish requirements
- March 2000: Publish training aid

C. Develop a job aid for certification engineers and designees to use in the evaluation of the adequacy of wire systems installation drawings and instructions for continuing airworthiness.

PLAN DETAILS, TASK 7.C.:

Responsible party: Aircraft Certification Service

Schedule:

- September 1999: Publish job aid

Appendix I: Summaries of On-Site Evaluations
of " Aged" DC-10, DC-9, B727

Aging Airplane Systems Evaluation Report - Boeing (McDonnell Douglas) Model DC-10

Evaluation Date: March 16th - 19th, 1998

Airplane Identification: Make/Model: McDonnell Douglas Model DC-10-10 Ship "A"
Airframe Hours: 60,397
Airframe Cycles: 25,075

Airplane Identification: Make/Model: McDonnell Douglas Model DC-10-10 Ship "B"
Airframe Hours: 62,056
Airframe Cycles: 24,260

Airplane Identification: Make/Model: McDonnell Douglas Model DC-10-10 Ship "C"
Airframe Hours: 62,997
Airframe Cycles: 24,993

Evaluation Team:

Mr. Alan Sinclair, FAA Systems & Equipment Branch, Mechanical
Mr. Gregory Dunn, FAA Standardization Branch
Mr. Brian Overhuls, Electrical Engineering, Douglas Products Division
Mr. Elvin Wheeler, FAA Systems & Equipment Branch, Electrical
Mr. Robert Jones, FAA Systems & Equipment Branch, Mechanical
Mr Bill Rau, FAA Aircraft Evaluation Group
Mr. Bruce Powell, Boeing Maintenance Engineering Requirements
Mr. Matt Goodshaw, Boeing Maintenance Engineering Requirements
Mr. Robert Boles, Electrical Standards Engineering, Boeing Commercial Airplane Group
Mr. Wilfred Gibson, Post Production Engineering, Boeing Commercial Airplane Group
Mr. Fred Moore, Product Support, Boeing Commercial Airplane Group
Mr. Mick Conahan, Product Support, Douglas Products Division

Summary of review of DC-10 ships "A", "B", "C" and MD-11 "D".

The areas reviewed included the electrical grounds, static grounds, wiring & connectors, hydraulic lines & actuators and cables, pulleys & brackets. Major structural and systems modifications were being accomplished on this airplane during the team's evaluation.

It must be noted that the observations below were made while the airplane was undergoing maintenance associated with a "heavy maintenance visit" and several maintenance work orders had not been completed. The condition of the airplane noted is <u>not</u> reflective of the condition that the airplane would leave the maintenance facility.

On ship "B" the areas reviewed included;

- From the EE-Bay to the tail, both above and below the floor and the flight deck.
- The wheel wells.
- The leading and trailing edges of the wings.
- The horizontal tail and jack screws.

On ship "A" the areas reviewed included; (Note: this aircraft was missing the engines and interior components, otherwise it was in serviceable condition.)

- The EE-Bay and aft face of the cockpit breaker panel, the ceiling wiring and the Center Accessory Compartment, (CAC) electrical bay forward of the wing.
- The wheel wells and landing gear.
- The leading and trailing edges of the right wing.
- The aft fuselage compartment above the APU, aft of the pressure bulkhead.

On ship "C" the areas reviewed included;

- The wheel wells.

On ship "D" the areas reviewed included;

- The front and rear spar area of the right wing.

On ship "B", Mechanical items found;

- The hydraulic lines on the right side flap, at the fuselage were rubbing on the inside of the coil. Same condition was found on the left side flaps of ships "A" and "C".
- The cable pulleys on the leading edge, outboard of the engine have bad bushings/bearings.
- In the EE-Bay there was a broken pulley bracket and a damaged pulley. (These items were tagged for repair.)
- On the trailing edge of the right wing, the pulley brackets were loose. Since the cables and the pulleys were removed, it is presumed that the brackets were loosened as part of the Mod. The other ships showed no signs of loose brackets.
- On the horizontal tail trailing edge, numerous loose and missing bolts were noted in the linkage system downstream of the flight controls. The Lead mechanic for the aircraft confirmed that this was part of the Mod.

The pneumatic duct insulation covering was damaged and missing in some areas.

<u>Electrical Summary</u>

Electrical Subsystems - Aging related findings & observations

Approach: Visual observations and electrical measurements made to numerous electrical ground points. No specific system by system evaluation was performed.

Findings & Observations:

- Main wheel wells showed signs of corrosion on some of the connectors shells, backshells and contacts. These conditions are expected in such a harsh environment.
- The wires in the wheel well areas appear to be "stiff". Several wires were observed to have cracks, though it appeared that no conductors were exposed. (Note: Care should be exercised when removing or disturbing wiring harnesses in these areas to minimize the possibility of insulation cracking.
- Cables (coaxial/shielded and jacketed cable) with splits in the outer jackets were observed in the wheel wells which exposed the shielding braid. No signs of shield corrosion were noted. This would suggest that the damage occurred during maintenance action.
- Some connectors in the pressurized area were observed to have splits in the rear of the connector's grommet material. This condition appeared to be caused by the tension from the wires being secured to the single leg strain relief on the backshell.
- There was considerable dust accumulation throughout the pressurized area. (Example: under the pedestal in the flight deck, CAC and the E/E-Bay, and the over head ceiling panels.)
- Stiff wires were also observed in the pressurized area.
- Ground measurements were made on two aircraft: one undergoing modification, and the other in storage. Over 50 ground resistance measurements were made in the leading edge and trailing edge of the wing, wheel wells, CAC and the aft fuselage compartment. No measurable resistance was noted (less than 10 milliohms).

Itemized list of electrical findings on aircraft "B" DC-10

L/H wheel well and trailing edge of wing

- Corrosion was found on the backshells and the contacts.
- Cracks were found in the wiring insulation on wire number.
- Damaged cable jacket with exposed shields.
- ELF/FL actuator connector strain relief was missing.
- Broken wires were found leading into connectors.
- Numerous wires were found with cracked and flaking outer extrusion layer.
- Missing wire bundles clamps were noted.

R/H Aft wheel well

- ADF Sensor antenna coax had a split outer jacket, R/H side #1 antenna.

The wire bundle on the table

- The end service panel wire No. 1022H22 had cracked insulation at the end of a splice.

Station 1100 lower cargo area

- Plastic tie wraps were loose to the touch.

Center Accessory Compartment (CAC)

- The connectors on the disconnect panel had splits in the grommets caused from the tension on the wire being secured to a single leg backshell.
- Discolored insulation was found on the power feeder terminal.
- The rack and the connectors were covered with a brown sticky substance.

Electrical Bay in the aircraft nose

- The wires leading into the terminal modules were covered with dust.
- Metal shavings from a mod were found on the surface of the wire bundles.
- The yaw damper unit was missing the tie wraps on the backshell.
- On the left hand side pack #1 the wiring had a 90 degree radius bend with cracked outer insulation.

Itemized list of electrical findings on aircraft "C".

- L/H wheel well wires had cracked & flaking outer layer of insulation (dual extrusion layer). Inner insulation was intact.
- On the lower bulkhead below the accumulator, a cracked wire bundle was found on "B", but was not observable on any other aircraft due to silicon tape wrap covering the wires.
- The Backshells in the L/H wing root showed signs chemical corrosion (Disconnect bracket with 4 connectors). However, the connector contacts showed no sign of corrosion.
- A kinked wire was found with split insulation which exposed the conductor. It appears to have been caused during maintenance. The wire ends at a terminal strip (AEP9101-503 Wire Assy. No.)

R/H Wheel well and wing root

- No wire bundles were found on the right side to verify the cracking which was found on ship "B".
- The connector backshells showed little or no signs of corrosion.

- No corrosion was found on the contacts.
- No wire insulation cracks were found.
- No cable insulation cracks were found.
- On the terminal strip below the ground #4822, no wires with cracked insulation were found.

Ship "D", MD-11

- Checked four static grounds, no failures were found.

Itemized list of electrical findings on aircraft "A"

R/H Trailing edge.

- 5 static grounds on the spoilers were checked and were found to be OK.
- 1 of the 2 static grounds on the spoiler, outboard of the engine was broken. The strap looked to be too short.
- PVC conduit was found running the length of the cabin with a 2 conductor ground wire installed.
- Coax cable was found to within 1/2" of the control cables in the EE-Bay, no positive support noted.
- In the waste tank compartment/fluid level sensor connector was corroded.
- EE-Bay, four broken plastic wire bundle clamps were found.
- EE-Bay, three cables with damaged jackets and exposed shields were found.

Wing leading edge.

- Measured the resistance of 12 ground studs, 5 of which were at the refueling panel, no faults found.

CAC forward of the wing.

- Measured 23 ground studs. No faults were found.
- Overall the wires were in very good condition, just a lot of dust and grime.

Flight Deck

- Dirt, dust on the wire bundles, but no cracking of the wires noted.
- The breaker panel, AC bus 1 tank #3 showed evidence of heating on the power leads and some of the wires had 90 degree bends.

Aft cargo inspection of systems below lavatories

- Evidence of blue waste water contamination was found on the wires.
- Connectors and wire bundles have evidence of blue waste water contamination.
- Contacts showed signs of corrosion.

Aft fuselage compartment

- Several wire bundles were examined with no evidence of cracks or broken wires noted.
- Four grounds were checked and no faults were found.

Aging Airplane Systems Evaluation Report Boeing (McDonnell Douglas) Model DC-9

Evaluation Date: April 7th - 8th, 1998

Airplane Identification: Make/Model: McDonnell Douglas Model DC-9-33
Airframe Hours: 70,410
Airframe Cycles: 66,242

Evaluation Team:

Mr. Alan Sinclair, FAA Systems & Equipment Branch, Mechanical
Mr. Gregory Dunn, FAA Standardization Branch
Mr. Brian Overhuls, Electrical Engineering, Douglas Products Division
Mr. Elvin Wheeler, FAA Systems & Equipment Branch, Electrical
Mr Lee Koegel, FAA Aircraft Evaluation Group
Mr. Bruce Powell, Boeing Maintenance Engineering Requirements
Mr. Matt Goodshaw, Boeing Maintenance Engineering Requirements
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Mr. Mick Conahan, Product Support, Douglas Products Division

DISCUSSION

It must be noted that the observations below were made while the airplane was undergoing maintenance associated with a "heavy maintenance visit" and several maintenance work orders had not been completed. The condition of the airplane noted is not reflective of the condition that the airplane would leave the maintenance facility.

April 7th through 9th, 1998: The purpose of the visit was to survey aging DC-9's undergoing heavy maintenance as part of the FAA's aging aircraft systems evaluation program. The team split into two small groups, an Electrical team (Dunn, Wheeler, Boles, Gibson, Overhuls and Conahan) and a Mechanical/Hydraulic team (Sinclair, Koegel, Moore, Powell and Goodshaw). The Electrical team concentrated on the wheel wells, avionics compartment, flight deck, circuit breaker panels and wing leading edge.

April 8th: The electrical team surveyed the engines, pylons, passenger cabin and tail cone areas. Connectors, terminals and ground studs in the tail cone area exhibited considerable amounts of corrosion as did most metal components in this area. The wire in the tail cone was in very good condition. Six ground resistance measurements were taken on corroded ground studs in the tail cone, and three of the six measurements exceeded 0.5 milliohms. The general-purpose wire used on this airplane was manufactured to Douglas specification number 7484444 (Quad-Four), a PVC-Nylon Braid-PVC construction. There were rare occasions where cracks could be found in the outer layer of extruded PVC with no evidence of damage occurring to the inner nylon braid. Overall, the wire throughout the airplane was in very good condition.

April 9th: The electrical team surveyed the cargo compartments, rudder and horizontal stabilizer in addition to the wheel wells of other DC-9's in the hanger. Chafed wires with exposed conductors were found on one of the other airplanes at a bulkhead connector inside the wheel well. The damage was caused by the wheel contacting the wires after retraction of the landing gear.

SUMMARY OF ELECTRICAL TEAM OBSERVATIONS:
The following is a summary of age-related findings and observations associated with electrical system components:

General Summary
Where unplugged connectors could be observed no corrosion or deteriorated backshell insulators were observed within the pressure vessel. Cracked extruded nylon insulation was observed in the wiring under the glare shield and in some tight turn radii wiring under the floor panels. In wire of this type it is impossible to observe cracking of the center conductor due to braided fiberglass insulation layer. Metal shaving contamination was evident on several wire bundles. Several ground studs in the flightcrew circuit breakers panel were checked for resistance and no observable resistance was noted. An accumulation of dust and dirt was noted forward of the rudder pedals and in the wire bundles under the center console. The circuit breaker panel also had a significant accumulation of dust.

Connectors and wiring from several engines did not show any significant deterioration. The wire harnesses that were sent to the shop for repair showed some areas of chaffing and cracking of the outer insulation. Where harnesses were repaired, the chaffed wiring was removed.

- Most connectors and ground studs in the tail cone area showed signs of corrosion. These conditions are expected in such a harsh environment.
- Six ground resistance measurements were made in the tail cone area using an Avtron bonding meter. Three of the six measurements exceeded 0.5 milliohms.
- Cracks were observed in the outer layer of insulation on some wires; however, these cracks did not appear to expose the conductor.
- There was a moderate amount of dust accumulation on wires inside the pressurized area (flight deck instrument panels, avionics compartment and cargo compartments).

ELECTRICAL TEAM REVIEW - DETAILS:

<u>DC-9-33</u>

Left Hand Wing Leading Edge
- Main wire type is Douglas Specification 748444 (PVC/Nylon Braid/PVC).
- Plastic ties and plastic clamps used throughout are in good condition.
- Wire attached to the outside of a wire bundle using plastic ties and not installed under the clamps.

- Three ground studs showing signs of corrosion.

Right Hand Wing Leading Edge
- Connector with discolored finish and signs of corrosion on the backshell.
- Wire supports at ends of conduits are pulling wire against side of conduit instead of center.
- Connector with signs of corrosion on R/H wing tip.

Right Hand Wing/Body Fairing
- Unsupported wires running into a nylon conduit.

Left Hand Wing/Body Fairing
- Connector with signs of corrosion on internal threads.

Nose Wheel Well
- Wire installed under tension with severe bend radius.

Main Circuit Breaker Panel
- Overheated wire terminating to circuit breaker # B1-334.
- A metal shaving was found shorting pins of the call button switch in the flight attendants interphone panel.

Left Hand Engine
- Improperly stowed connector (compressor region, 8:00 position).
- Wire bundle clamp with split cushion material (compressor region, 2:30 position).

Right Hand Engine
- Improperly stowed connector (compressor region, 8:00 position).

Right Hand Pylon
- Wire with split outer insulation exposing nylon braid beneath.

Tail Cone
- Multiple ground studs and connectors with corrosion.
- Ground stud resistance measurements
  0.761 milliohms (No. 652)
  0.330 milliohms (No. 662)
  1.370 milliohms (No. 1522)
  1.750 milliohms (No. 1521)
  0.040 milliohms (No. 1515)
  0.003 milliohms (No. 1514)
- Multiple improperly stowed connectors to High Frequency (HF) System equipment which had been deleted.
- Two broken plastic wire bundle clamps.
- Wire in good condition.

Passenger Cabin

- Most wire bundles are routed through nylon tubes

Findings Cockpit Area

- Circuit breaker panel - dirty.
- Wire bundles by the first officer’s rudder pedals had significant metal shaving contamination.
- Sheet metal screw in close proximity to wire bundle to the right of the first officer’s control column.
- Flight-crew compartment forward of the rudder pedals showed a heavy dust and dirt accumulation.
- Circuit breaker panel (ref B1-334 20 amp breaker) on the load side noted evidence of over heating of the wire, (for right windshield anti-ice circuit).
- Checked the grounds at the floor rear of the circuit breaker panel, no significant resistance noted.
- Pilot/Attendant call button contacts on the circuit side of the interphone panel, noted a corkscrew metal shaving shorting two terminals, it was removed.
- Evidence of outer insulation layer cracking in the wire bundles running under the cockpit floor.
- Wires under the glareshield had sharp radii bends - this was not a wide spread problem.
- An overhead air line aft of the crew door had several deep dents.
- Cracked outer insulation jacket noted in the APU harness.

SUMMARY OF MECHANICAL TEAM REVIEW - TEAM OBSERVATIONS:

Horizontal Stabilizer

- Hydraulic lines to sensor had slight weep at the “B” nut.
- Metal shavings left on the movable surfaces from newly machined hole.
- Surface corrosion on an aluminum conduit running up the vertical tail’s leading edge.

Tailcone Area

- Nothing unusual.
- Hydraulic lines in good condition.

Right and Left hand wheel well, under wing fillet and rear spar

- Moderate corrosion on hydraulic line “B” nuts.

Left Hand wing leading edge

- Nothing noteworthy found.

Cabin Area including the upper deck cargo door

- Accumulation of dirt and nicotine.

Right Hand wing leading edge

- Nothing noteworthy found.

Cargo Compartment

- Control cable at station 955 just aft of the lower cargo door, can be deflected into system return pipe, but no evidence of rubbing noted.

Aging Airplane Systems Evaluation Report-Boeing Model 727

Evaluation Date: April 15-17, 1998

Airplane Identification: Make/Model: Boeing Model 727-200
Airframe Hours: 27032
Airframe Cycles: 20691

This airplane was originally delivered as a passenger airplane and was converted to freighter configuration in 1985. The aircraft also incorporates "hush kit" engine modifications to allow compliance with the noise requirements of 14 CFR Part 36.

Evaluation Team:

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Background

An evaluation of a Boeing Model 727-200 airplane was conducted to obtain qualitative evidence associated with the effects of aging on non-structural systems and equipment. This evaluation was conducted as part of the aging, non-structural systems study that was initiated in response to recommendation 1.9 of the report of the White House Commission on Aviation Safety and Security, dated February 12, 1997. Since this airplane is still in service, the evaluation was conducted primarily via visual inspection. Destructive forms of inspection such as disassembly of electronic or mechanical equipment was not performed. A total of 32 anomalies of varying significance were identified. A review of these items resulted in the determination that 20 were directly attributable to age, with the remaining 12 primarily the result of non-age related phenomenon. These observations are described in the following text.

It must be noted that the observations below were made while the airplane was undergoing maintenance associated with a "heavy maintenance visit" and several maintenance work orders had not been completed. The condition of the airplane noted is <u>not</u> reflective of the condition that the airplane would leave the maintenance facility.

Aging-Related Observations

Avionics Systems and Installation (Exclusive of Wiring)

1. Antenna mounting surfaces on the lower lobe of the fuselage exhibited corrosion to the extent that grinding was needed to allow proper electrical bond between the airframe and the corresponding mounting surface of the antenna.

2. Horizontal Stabilizer: Continuity measurements of the static dischargers on the horizontal stabilizer indicated that the two inboard units on the left side and the outboardmost unit on the right side were open circuited.

Electrical Wiring

1. Tail cone section: Wiring associated with the tail skid actuator was covered with what appears to be hydraulic fluid. The nylon outer "skin" of the Boeing Material Specification (BMS) type 13-13 wire exhibited signs of cracking and, at certain locations, flaked off. The primary insulation of BMS 13-13 wire is Polyvinyl Chloride (PVC) which resides under the nylon layer. In this case, the PVC insulation appeared to be undamaged.

2. Numerous locations: Numerous ground stud build-ups exhibited signs of corrosion (rust). The grounds were not disconnected so the condition of the interfacing surfaces of the buildups could not be ascertained. A true bonding meter was not available so bond resistance measurements could not be conducted.

3. Horizontal stabilizer: The insulating jacket of one shielded cable was split, exposing the braided shield beneath.

4. Various Locations: Additional occurrences involving cracking of the clear nylon "skin" on BMS 13-13 wires were noted. In all cases, the PVC insulation did not appear to be damaged. Examples of this observation were found at the following locations:

> Flight Deck: One BMS 13-13 wire observed to have a cracked outer jacket. Primary PVC insulation was undamaged.
>
> Wing Leading Edge Area: Wire bundle W568 at wing station 615 of right wing.

5. Air conditioning pack compartment: One BMS 13-51 wire exhibited a radial crack in its insulation adjacent to the connector at the end of the associated wire bundle. BMS 13-51 wire incorporates polyimide insulation.

6. All areas below main deck floor: Wire bundles in the lower lobes of the airplane are covered with metal filings, and shavings. It is highly likely that over time, some of the metal waste has or will work its way into the wire bundle. It appears that wire bundles accumulate metal waste as the result of drilling and grinding during previous modification and maintenance activities. It should be noted that the repair station did cover major wire bundles with plastic wrap in areas that exposed the wire bundles to maintenance work.

7. Forward cargo compartment, left sidewall: A large wire bundle had sagged excessively between wire bundle support clamps. At fuselage station (STA) 545, water line (WL) 179, left buttock line (LBL) 58, the wire bundle rested on the corners of a bracket that secures pitot static tubing to the fuselage stringer at this location. It should be noted that this problem is only partially attributable to age. The sagging was also exacerbated by the cargo conversion modification which combined several wire bundles into one large bundle. The excessive weight of the bundle in conjunction with the use of wire bundle support clamps that were inadequate for the wire bundle size, contributed significantly to the problem.

8. Electrical/Electronics Compartment: Engine No. 2 generator power feeder was found to be resting against the side of the hole in the floor beam through which the feeder was routed. The grommet that was originally installed to protect the feeder had worked loose, exposing the feeder to metal floor beam structure.

9. Electrical/Electronics Compartment: Washers installed on terminals L1, L2, L3 of No. 2 Bus Tie Breaker (BTB) C848 exhibited significant amount of corrosion (rust).

10. Main Deck Cargo Compartment: Bonding jumper termination at ground stud was found to be loose on the window plug at window position 13 left. The bonding jumper associated with the window plug at position 7 left was broken. It should be noted that these discrepancies would not occur on a passenger airplane since the window plugs are unique to the cargo conversion modification.

11. Engine No. 2 Installation: Bonding jumper termination at the aft end of the S-duct, forward of the rubber flex coupling is loose. This jumper electrically bonds the metal band clamp on the engine intake side of the rubber flex coupling, to the S-duct. It does not appear that removal of engine no. 2 requires loosening of the bonding jumper at the S-duct.

12. Right Wing: Two broken nylon "P" clamps were found at right wing station 251 along the rear wing spar. The first was located six inches from ground stud GD90AC and the second approximately twelve inches outboard of the first. It appeared that the clamps had become hard and brittle over time and eventually failed. Exposure to lubricants and/or hydraulic fluid may also have contributed to the deterioration of the clamp material. The associated wire bundle was left unsupported for approximately four feet.

13. Aft Lower Lobe Cargo Compartment: Wires providing electrical power to cargo compartment light fixtures exhibited signs of heat deterioration near the light fixtures. In addition, one of these wires was contacting flight control cables between STA 990 and 1010, at WL 200, right buttock line (RBL) 15.

14. Flight Deck: One wire of the coiled window heat wire assembly for Captain's No. 2 (sliding) window had cracked insulation with conductor partially exposed. This anomaly was observed approximately two inches from the terminal lugs at the end of the wire assembly.

<u>Mechanical/Hydraulics</u>

1. Various Locations: Surface corrosion on hydraulic “B” nuts and fittings (unions, tees, X-fittings, etc.). These fittings did not appear to be made of stainless steel. Examples of such corrosion are found at the following locations:

> Forward Air Conditioning Pack Compartment, Left Side: Corrosion observed on left and right leading edge flap/slat pressure lines and standby system supply line to leading edges. Corrosion also observed on nose landing gear up and gear down supply lines in this area.
>
> Main Wheel Well, Left Side: Corrosion was observed on “B” nuts on bottom of ground spoiler control valve.

2. Vertical Stabilizer: Surface corrosion on fastener that attaches summing link to the upper rudder power unit.

3. Vertical Stabilizer: Surface corrosion of rod end bearing on output rod of lower rudder standby power unit.

4. Right Wing Near Main Wheel Well: “A” hydraulic system return line from heat exchanger shows evidence of corrosion with pitting. The condition occurred approximately one foot outboard of the main wheel well, under the first tubing clamp. Also observed in this area was wear and fretting of the main landing gear hydraulic supply line under a clamp located immediately adjacent to the aforementioned “A” hydraulic system clamp.

Non-Age Related Observations

In addition to the observations described above, the following discrepancies were identified which are not considered to be age related. These discrepancies will not receive further consideration by the aging systems study but are presented to the maintenance facility and the airplane operator for consideration during routine maintenance.

1. Main Deck Cargo Door: Support bracket associated with cargo door conduit was broken.

2. Left Main Wheel Well: Wire bundle was contacting structure at forward bulkhead.

3. Flight Deck-Behind P5 Overhead Panel: Interference between wire bundle W630 and the backside of connector D4060P when P5 panel was raised to the closed (normal) position. A small amount of chafing damage was observed on W630.

4. Air Conditioning Pack Compartment: Wire bundle associated with connector D1914 was installed with excessively short bend radius.

5. Air Conditioning Pack Compartment: Ground wire of compartment light was broken.

6. Air Stair Compartment: Two wires were installed in a manner that resulted in chafing against bleed air valve at approximately STA 1223, WL 205, left side of airplane.

7. Rear Pressure Bulkhead: Wire cushion clamps were not secured to structure.

8. Rear Pressure Bulkhead: Wire bundles were loose in their respective clamps in the raceways near the crown area.

9. Forward Lower Cargo Compartment, Left Sidewall: Wire bundle at STA 680 was resting on structure due to lack of support.

10. Outer sheath of the wire associated with switch on the forward edge of the main deck cargo door frame on fuselage was worn through.

11. Wire bundle descending down right sidewall from main deck to aft lower cargo compartment at approximately STA 950D was found to be chafing against structure. The chafing occurred at the access hold nearest the sidewall where sharp edges were observed on the structure in this area.

12. Horizontal Stabilizer: Electrical wiring conduit near stab trim jackscrew was open at upper end and subject to the entry of water. There did not appear to be any drain holes or other means of preventing water accumulation at the lower end of the conduit.

Miscellaneous Observations

1. Inspection of several receptacles and plugs that were disconnected as part of maintenance work revealed clean, bright contacts with no sign of corrosion.

2. Significant accumulation of dust behind flight deck circuit breaker and overhead panels, but no obvious evidence of cracked or overheated wiring.

Conclusions:

The observations described above clearly indicate that the number of age related anomalies in non-structural systems is greatest with electrical wiring and installations, followed by hydromechanical tubing and fittings. This situation was not unexpected, since maintenance programs currently in place for transport airplanes do not provide for detailed periodic, preventative maintenance of electrical wiring and fluid lines. Maintenance of such items have traditionally been limited to repairs conducted in response to wiring or tubing failures that resulted in loss of function of the system associated with the wire bundle or fluid line. The operator's maintenance program does call for visual inspections of hydraulic system equipment for signs of corrosion. Pass/fail criteria are not provided, however, and the variability of human judgment determines the extent to which corrosion of hydraulic components is allowed to exist.

Despite the lack of specific wiring and fluid line maintenance requirements, the majority of age related anomalies identified on this airplane are considered minor in nature. Two extenuating factors must be considered, however, when attempting to draw conclusions based on the anomalies described above. First, at the age of 19 years, this airplane has not quite reached the end of the airframe manufacturer's design life. Second, this airplane was involved in cargo operations for the great majority of its service, resulting in relatively low utilization over its life (27032 hours/20691 cycles). In contrast, a typical 19 year old Boeing 727 airplane engaged in passenger carriage would have accumulated on the order of 56,000 hours and 32,000 cycles. With these factors in mind, the following conclusions are offered:

A. At 19 years of age, the electrical wiring and hydromechanical fluid lines do not exhibit significant age-induced deterioration.

B. The onset of minor wiring defects (cracking of outer "skin" of BMS 13-13 wire, wire chafing due to sagging bundles, etc.) indicates that as this airplane's age exceeds the manufacturer's design life, increased attention to the condition of electrical wiring and related equipment is prudent.

C. External factors which are part of normal airplane operation can create situations that, over time, can result in damage to wiring. The most obvious example is the accumulation of particles of metal waste on and in wire bundles that could damage wire insulation and provide an electrical path for short circuits.

D. Aging affected the hydromechanical fluid lines and fittings of this airplane to a much lesser extent that electrical wiring and was limited primarily to cosmetic corrosion. This conclusion does not apply to the operational condition of hydromechanical components (pumps, valves, actuators, etc.) since internal inspections and/or testing of this equipment was not conducted.

Appendix II: Summary of Principal Maintenance Inspector Workshop.

BACKGROUND-- As part of the Aging Systems investigation, it was determined that input from the Principal Maintenance Inspectors (PMI's) should be obtained to find out their concerns with regards to aging systems. A two day meeting was held in Seattle, Washington, March 31-April 1, 1998. There were 37 attendees, mainly from Flight Standards, the Aircraft Evaluation Group and the Aging Systems Team.

POLL OF LEADING 4 AGING SYSTEMS PROBLEMS The PMI's were asked to fill out a form listing the top four aging systems problems, to assess in writing their areas of greatest concern.

The top four concerns were as follows:

1. Engine repairs, especially JT-8D engines
2. Wiring and associated components
3. Repair stations and their oversight
4. Flight controls/hydraulic systems

DISCUSSIONS AND CONCLUSIONS--Some attendees voiced the opinion that we do not have an aging systems problem. This is based upon the fact that aging is caused by exposure to harsh vibration, temperature, and moisture environments that exist in areas such as engine pylons, wing leading edges, wheel wells, etc. Components in these areas age more rapidly than components in more protected areas of the airplane. Components in the harsh environments already have aged before the design life of the airplane has been reached, and the operator's reliability program already addresses "aging" in the harsh environment areas. If the reliability program already addresses aging in certain (harsh environment) areas, it could also address the rest of the airplane.

Additional discussion by the group resulted in the conclusion that aging systems should be concerned with finding latent failures that could result in safety problems. For most components and systems, redundancy, or scheduled/on condition maintenance is sufficient to prevent a latent component failure from becoming a safety hazard. In certain cases, however, latent failures may occur which could present safety hazards. An example would be fuel pump cables chaffing against conduit in a fuel environment. Loss of function of the cable may not be unsafe because of redundant fuel sources, but the "arcing and sparking" could cause a fire which would be a safety hazard. Our task would be to find a way to prevent the safety hazard from occurring.

A major concern of several PMI's was repair stations, especially their use in the repair of rotating parts for engines, such as the JT-8D. The use of repair stations by the airlines is increasing. In 1990, repair stations performed 37% of air carrier maintenance; by 1996 the figure was 46%. More than 2,500 domestic and 270 foreign repair stations do work for the air carriers. A great deal of "aged" aircraft, aircraft engine and system component maintenance is being done at these facilities.

Some participants thought that the aging systems group should undertake an investigation of the repair stations to ensure that these facilities are complying with their air carrier customer's continuing airworthiness programs. Other participants considered the increased use of repair stations to be a matter of routine FAR Part 145 compliance and oversight, and outside the scope of the aging systems charter. Additionally, they point out that other FAA teams are already reviewing repair station maintenance.

Wiring and associated components such as circuit breakers and connectors were considered by the PMI's to be an important aging system concern. There was a general consensus that zonal inspections with visual inspection techniques by non-expert maintenance personnel may not be adequate to find problems and avoid future hazards. This was considered to be a good area for research. It was stated that since aging wiring and associated components may be damaged if moved or manipulated, an intrusive inspection may cause harm to in-service airplanes. Therefore, obtaining airplanes or wiring/associated components thereof which are being retired from service and doing research was seen as a good idea. It was also stated that there was a need for tools that could aid in finding latent failures that could result in safety hazards.

The attendees agree that the FAA should follow the Gore Commission recommendations. It was agreed that the first focus of the aging systems group should be airplanes that are now at or near their design lives, but that additional activity may be needed to address aging problems of later model airplanes, such as HIRF/Lightning protection. There was discussion about the FAA's ability to do additional reviews to find aging system problems. There was a desire to have industry do the bulk of the review because of limitations in FAA staffing. However, other participants wanted to retain FAA's ability to make independent findings and recommendations if the evidence supported those findings.

ADDITIONAL RECOMMENDATIONS-- Several recommendations were made by the group in addition to the Gore Commission recommendations. The Recommendations are listed below.

1. FAA and industry need to form a joint working group to develop a better reporting system for aging aircraft to identify trends.

2. Form a joint FAA-industry working group to make improvements to Chapter 20 wiring repair practices.

3. Develop criteria for zonal inspection, joint FAA-industry working group.

4. Form a joint FAA-industry working group to review human factors associated with repair and maintenance tasks performed by maintenance personnel, especially those at repair stations.

Appendix III: Meeting minutes, Boeing.

<u>BOEING AGING AIRCRAFT SYSTEMS MEETING #1</u>
<u>March 6, 1998</u>

<u>DC-10 Evaluation, March 16-21</u>

The FAA has been developing the checklist and plan through the assistance of the Principle Maintenance Inspectors (PMIs) and Principle Airworthiness Inspectors (PAIs). Elvin Wheeler will be setting up a side meeting at the end of next week at Douglas Products Division (DPD) to further refine and focus the checklist, agenda and define DPD participation for the DC-10 visit. The checklist is intended to be a living document to be updated as we progress up the learning curve.

The perception of areas that should be inspected includes:

* unpressurized zones
* dynamic areas where mechanical movement occurs (ie landing gear bays)
* equipment and components adjacent to modification or repair locations
* circuit breakers and switches that are beyond design lifetimes
* collection of any throw away components

Since time aboard each aircraft is limited we want to prioritize visual inspection of in-place items, coordinate requests to take on-board measurements with a repair station engineer and operator representative up front (targeting components slated for removal) and collect the throw away items for test and analysis at our convenience. There are also items like wiring and connectors that are not reported because they are not warranty items, there is no reporting chapter and it is easier to fix and forget.

Alex Taylor and Darrel Santala suggested changes to the checklist regarding wiring observations to add standardized definitions and classifications of damage with types of components and locations to inspect.

Brian Boyle discussed the ASTA inspection approach where multiple teams were created. Customer Service worked with the maintenance team while other engineering teams combed the airplane for damage, labeled and photographed items found. They had taken over 2000 photos in the development of the 747-SL-20-048 Service Letter - Inspection of Wiring on High Time Airplanes.

Digital cameras will be used to document items and electronically transmit pictures to experts for analysis/comment.

<u>Overview of Plan Beyond the FAA June 30 Final Report</u>

There is a nagging concern with Gore Commission, NTSB and FAA that the number of older planes remaining in service beyond their design life is increasing and FAR 25.1529

(Instructions for Cotinuing Airworthiness) is not adequate. The FAA's aging system study requires a significant response in identifying whether a problem really exists and offers certain opportunities to initiate research activities. The plan beyond the final report still has to be developed.

Approach to Latent Faults

Darrel Santala addressed concerns regarding the attached Design, Manufacture and Maintain cloud chart (Design, Production, Maintenance Chart). The FAA is concerned that:

* the chart reflects what happens in current production and not necessarily what occurred twenty years ago
* Overhaul shops and mod centers are becoming stand-alone operations and are no longer associated with an operator’s identity
* inspection intervals are spreading out rather than converging
* redundant architecture does not adequately address effects of common mode failures (vibration, hydraulic fluid, etc. . .)
* separation between systems is used where practical, but there are locations where separated systems are brought together (i.e. engine pylon)

We have component design lives which are qualification tested but what are the appropriate maintenance plan adjustments when operating beyond the design life? The Boeing Company, Douglas Products Division (DPD) actually went back, committed resources to do the analysis, and created an Maintenance Review Board (MRB) document for older models.

Reliability Data

Don Gabel addressed the issue of reliability data. The SPARES organization has custodianship of the old R&M database. The discussion focused on whether a format can be developed to accurately identify failure rate variations with age and identified the following issues:

* Is existing data for older aircraft valid
* need to account for component upgrades (BFE radio equipment etc. . .) and incorporation of design changes and service bulletins
* is the problem bigger than the FAA and Boeing because it requires the airlines and industry groups to commit resources

The possibility of running a Proof of Concept (POC) program was explored. Assuming enough resources are currently available, a couple items that are expected to wear out (mechanical moving parts, flight controls, mech/hyd, etc. . . .) could be identified. A test database format built using an iterative process to define parameters. We've got a new tool if it works; if it doesn't, we could potentially dismiss the examined systems as aging concerns. There is a hesitation to make recommendations based on such a limited sample size. DPD had a statistician develop statistical viability numbers for their Fuel System working group for as small as 50 aircraft.

Please note candidate items can not be covered by the maintenance plan. We are most likely dependent upon operator participation and asking a third party for commitment of resources. The FAA is in the best position to initiate a research program as part of their report recommendations.

Wire Reliability

Wire failure modes change depending upon wire type; therefore, reliability numbers just get you in the door. Many more details and questions have to be addressed.

When airlines repair wire, the splices show up disproportionately as a cause of in-service events due to improper parts substitution, usage and poor practices (improper splices). Every connection is a reliability point and you are more likely to find broken wires at clamps or structure penetrations.

Aircraft Evaluation Group (AEG) Input to Checklist

The AEG wants to add the following checks:

* hydraulic tubing and flexible hoses
* control cables
* wall thickness (Group dismissed wall thickness as an issue based on in service experience)
* Integrity of single load path
* review D check packages to determine coverage of control surface actuator full authority checks

Also noted was the WHCSS definition of a system - if it isn't primary structure it is a system.

Tools

The computer wire tester used in the military's version of D check to measure impedance and perform high potential tests was discussed briefly. The Military also has a practice of intentionally disturbing wire harnesses to expose problems rather than deal with intermittent failures leading up the hard over failure out in the field.

Alex Taylor noted that Boeing has intentionally cut insulation and wire with a hot stamp machine and cranked up the voltage - all you do is ionize the air at sea level.

Darrel Santala related that Boeing has equipment to measure integrity of shields.
Tools development and selection doesn't happen until we have defined the problems for which we are looking. Once the problem areas are identified, then the requirements for the tool can be developed.

BOEING AGING AIRCRAFT SYSTEMS MEETING #2
April 14, 1998

Recommendation for FAA Plan

Four concerns were identified during a discussion regarding the current capabilities of the National Aviation Safety Data Analysis Center (NASDAC) and reporting systems in general;

1) Existing databases do not provide for the identification of failure rates of equipment and failure trends. Non routine items are handled by paper and there are unique practices between operators. Better methods to disseminate data without mandatory reporting requirements should be explored.

2) That data be used properly to identify safety concerns and not become subjugated to political considerations or sensationalism. Fear is that every non routine card will be turned into an Airworthiness Directive. Assurances are needed that sound judgment and the ability to decide appropriate action and its timing must be preserved. The consensus is that this activity leads us back to an MSG-3 assurance plan process which sets up service/replacement intervals. Aging systems should be addressed directly without having rules written against the aircraft.

3) There is no current program to remove parts, return them to labs and determine performance. We want to selectively obtain parts exposed to high vibration, temperature, dirt, etc. Also, we want to identify areas that are specifically prone to latent faults and examine components to determine what is occurring. There is a need to recognize that disassembling systems and equipment typically introduces more problems; we would need airplanes/equipment that are going to be removed from service and scrapped.

4) Part of this should be educating the public about how continuing airworthiness and maintenance programs work. We need the ability to objectively say here are the facts and data which demonstrates that a problem either exists or does not exist. We would like to explore the possibility of using the Commercial Aircraft Safety Strategy Team (CASST) which has apparently been formed to work safety issues and educate the public.

Agree/Disagree with Gore Commission Recommendations

The team discussed each of the five recommendations within the Gore commission report, which recommended to *expand the aging aircraft program to include non-structural components, through steps including*:

1. *full and complete tear-downs of selected aircraft scheduled to go out of service*

   The team agreed to the benefit of tear-down inspection of aircraft systems but the details need to be worked out. Desire to focus activities using an MSG-3 type process to improve systems and maintenance; including tubing, clamps and wires as aging items. Operator experience indicates that it is unlikely to find a ten year old valve on a thirty year old airplane. This is due to existing proactive maintenance practices addressing the economics of replacing equipment during scheduled base maintenance rather than risk interrupting service by having to replace failed equipment in unscheduled flight line maintenance activities.

2: *establishment of a lead-the-fleet research program*

   The team agreed the research side has merit and discussed rumors of a Sandia National Laboratories research proposal to the FAA for development of new test equipment and methods to detect weakened insulation without disturbing wire bundles. Work has to be done to understand the problem and transcribe that understanding into real requirements for such a tool. Industry participation is pending FAA acceptance of proposal and funding.

3: *an expansion of FAA-DoD-NASA cooperative aging aircraft program*

   Already being done; there will be a conference in Williamsburg, Virginia at the end of August. This is a follow-on to further define roles and objectives discussed in the first conference. It was agreed that all of our activities to date are appropriate for this forum.

4: *an expansion of programs of the Airworthiness Assurance Working Group to include non-structural components*

   It was agreed that the FAA has to specifically task and set deadlines for an AAWG/AAC working group.

5: *and encouraging the development of modern technical means to ensure and predict the continued airworthiness of aging non-structural components and systems*

   The team agreed development of new technology (like eddy current testing on old planes on rotating parts) and new maintenance practices should be encouraged.

Top Four Aging Concerns

The team discussed what we consider to be the top four system/equipment aging concerns. They are:

1) Wiring: currently operators perform visual inspections and refer to Maintenance Manual, Chapter 20, and Wire Repair Manuals for guidance on wear limit recommendations which were developed from adoption of best practices. Generally, a cracked wire does not have to be replaced but a split wire must be replaced or repaired (spliced). A split wire is one where the conductor can be seen through the crack.

2) Connectors (wiring, plumbing etc. . .) in areas exposed to fluids and contamination during wash down are of special concern. Connectors are similar to the wire in conduits; problems are not detected unless inspected, inspections currently require disassembling the connection and typically introduces more problems than inspections detect/prevent.

3) Grounds and Ground straps

4) Circuit Breakers

Hoses and Control Cables were briefly discussed. The team consensus is that existing maintenance programs adequately address hoses. Control Cables are visually inspected and a rag is run along the cable to detect broken external strands. Internal cable problems are detected through observation of stretching or necking of the cable. Rigging problems also occur as the cable stretches and tension is decreased. Cables also have hard time replacement intervals. The Military may be developing an eddy current test tool and methodology to verify that cable internals are intact.

Appendix IV: NASDAC Study.

Background

A review of accident, incident, and service difficulty data was conducted in an attempt to identify trends that could associate aging of non-structural airplane systems with increases in safety related problems. This review was conducted as part of the aging, non-structural systems study that was initiated in response to recommendation 1.9 of the report of the White House Commission on Aviation Safety and Security, dated February 12, 1997. Data was extracted from databases accessible through the FAA National Aviation Safety Data Analysis Center (NASDAC). Databases that were considered relevant to the study of aging of non-structural airplane systems are:

- National Transportation Safety Board (NTSB) Accident and Incident Database
- FAA Accident and Incident Data System (AIDS)
- FAA Service Difficulty Reporting System (SDRS) Database
- FAA/NASA Aviation Safety Reporting System (ASRS)

Additional information related to airplane operating hours and cycles was obtained from the Airclaims Database, also accessible through NASDAC.

Retrieval of Service Difficulty Data by NASDAC

The initial philosophy behind the study was to use the data retrieval and manipulation capabilities of the NASDAC organization to perform a series of searches based on data requirements provided by the aging systems team. These requirements are listed in Attachment 1. The desired output would consist of computer data files that could be further manipulated and analyzed for age related failure trends using standard spreadsheet techniques.

Several shortcomings of the various databases were identified by NASDAC during its attempts at servicing the team's data request. Information related to the utilization rates of airplanes for prior years is not available in any of the NASDAC databases. Cumulative flight-hour and flight cycle totals are available in the Airclaims database but only for the present reporting period and only for airplanes that are currently in service. For example, it is not possible to determine the average number of departures per 727 airplane for the calendar year 1985. The lack of airplane utilization information for prior years creates a significant problem because most of the searches that were requested of the NASDAC organization use airplane utilization as a key search criteria.

The difficulties encountered while attempting to utilize NASDAC prompted the team to explore an alternative approach to retrieving and categorizing systems related service difficulty data. The use of the NASDAC Intranet Website provided the aging systems team with the benefit of direct access to the five databases most relevant to aging airplane studies.

Retrieval of Service Difficulty Data From NASDAC Website

The NASDAC Website is located on the FAA intranet at http://172.27.20.34/nasdac/. Although website users do not have all of the search and sort capabilities possessed by NASDAC programmers, data searches can be performed "on demand" from an intranet capable computer workstation. The submittal of verbal or written requests for data searches and the attendant turnaround time is therefore eliminated. Using the on-line data bases, the following approach was used:

- Determine what type of data is pertinent to aging of non-structural airplane systems.
- Retrieve data from databases available on the NASDAC website.
- Analyze data to identify associations between failure rates and airplane age.

Due to the limited data search and filtering capabilities afforded to website users, the data searches were based on the most important variables that are pertinent to aging of non-structural airplane systems. The following specific data was determined to be essential for establishing correlation between failures of non-structural airplane systems and airplane age:

1. Identification of airplane groups by make and model
2. Separation of accidents/incidents attributed to systems failures from events attributed to non-system (i.e. structural) causes.
3. The number of incidents/accidents involving non-structural systems for each airplane group for each year.
4. Average airframe age for each airplane group for every year for which service difficulty data is available. This figure must account for the addition of new airplanes to the fleet as well as loss of airplanes due to accidents, obsolescence, etc.

The desired outcome of these searches was a spreadsheet compatible report that could be sorted in accordance with any of the four variables.

During the attempt to retrieve the data listed above, another major shortcoming of the NASDAC databases was identified. The average airframe age for a particular airplane model for any given year is not available and cannot be readily extracted from data that is available. This is considered a major deficiency since the increase in the average airframe age is the primary variable on which the website review was to be based.

As more experience with the website was gained, additional difficulties were encountered. It is imperative that a reliable means of separating incidents/accidents attributed to non-structural systems failures from events instigated by other causes. The structure of the NASDAC databases does not readily accommodate such filtering. The structure of the NASDAC data limits this type of task to sorting incident reports by Air Transport Association (ATA) system codes (limited to the SDRS database) or manual review of text fields for descriptive evidence of non-structural system failures. Sorting by ATA system code is limited to SDRS since it is the only database with ATA system code fields. This method is highly inaccurate due to the fact that ATA codes do not reliably distinguish between non-structural systems and structural systems as defined by the aging systems program. As an example, failures of electrical wiring associated with door warning systems would be eliminated from the study since door warning is included under the same basic ATA code as door structures. Although more accurate, the manual review method is extremely labor intensive and is not amenable to automated data manipulation.

Summary

Meaningful studies of the effects of aging on non-structural airplane systems cannot be performed due to the lack of data that is fundamental to the identification of failure trends with respect to aging. The major difficulties described above, as well as additional difficulties encountered during the NASDAC evaluation are summarized in the following list.

Difficulties Encountered

- "Aging" of the fleet cannot be quantified since average airframe age for a particular model for prior years. It is therefore not possible to relate systems failure rates and incident/accident rates to airplane age.
- Annual departures, operating hours and cycles for previous years are not available. Failure trends of non-structural systems and equipment based on increases of these utilization factors cannot be established.
- Aging related phenomenon cannot be easily distinguished from non-aging related phenomenon. Accurate separation of aging related incidents/accidents from non-aging related incidents/accidents can only be performed by manual review of descriptive text fields of individual incident/accident reports.
- Databases contain many fields (e.g. SDR: 102 fields/incident, NTSB: 242 fields/incident) but many fields are unfilled.
- Reporting programs not well integrated between NTSB, FAA, operators, and manufacturers
- NTSB database (perhaps by design) only contains factual evidence. The final determination of the cause of an incident or accident does not get entered into the database.

Potential Solutions

- Establish new database to record historical information for all transport category airplanes, not just those in present day service.
  - -Date of delivery or entry into service
  - -Date of retirement, destruction, or other permanent removal from service
  - -Airplane make and model
  - -Airplane serial number
  - -Calculated average age for each model for each year since introduction into service

- Add provisions to existing databases to accommodate automated sorting of incidents/accidents to enable extraction of age-related incidents/accidents. For example, an additional "Yes/No" field could be added to "flag" incidents/accidents in which age deterioration of airplane systems played a significant role.

- Add a data field to the NTSB database that identifies the cause of incidents/accidents in a manner that accommodates automated sorting.

Attachment 1

AGING NON-STRUCTURAL SYSTEMS NASDAC SEARCH REQUESTS

We hope to test the effectiveness of our databases as well as establish the scope of any aging airplane problem with the following questions

Guidelines:

1. Only Transports produced by Douglas, Boeing, AIRBUS
2. Do not include non-accidental causes such as sabotage, military action, terrorism etc in the reported data.

STUDY QUESTIONS:

1. In 5 year cohorts, starting with the cohort of 737-100,-200 airplanes built between 1968 and 1973, chart the accident/incident rate (per million departures) of each cohort to the present using 5 year periods. Same chart for next two cohorts (‘74-’79, and ‘80-’84).

2. Same as (1) for the 747-100, -200, -300, SP airplanes starting with the cohort built from 1970-75, and including the next two 5-year cohorts.

3. Same as above for all 727 airplanes starting with the cohort built from 1970-75, and including the next two cohorts (5 year period).

4. For Boeing and Douglas transports starting with the cohort built 1970-75, track reported fires in 5 year increments to the present. Also, break out separate charts for 3 categories: 1) cause unknown, 2) faulty wiring/connector/cable/circuit breaker, 3) hazardous cargo. Chart same for next 3 each 5-year cohorts. Chart fire for overall transport category from 1970 to present with the same 3 breakout categories and a general category of “all fires”.

5. For Boeing and Douglas transports starting with 1970-75 cohort, track accidents/incidents attributed to or initiated by failure/malfunction of the flight control system in 5 year increments to the present. Chart next 3 each 5-year cohorts. Also chart transport category overall for 1970-present in the same area.

6. Build a spread sheet listing each accident in which a flight control upset was the primary cause or a contributing case in accordance with a NTSB accident investigation. Also list the specific cause/contributing factors and the age/cycles of the airplane.

7. Using the NTSB Aviation Accident Database, for transport category airplanes, for the period 1983 to present, provide a Microsoft Excel spreadsheet containing each accident or incident involving fire (exclude smoke in the cockpit reports). The spreadsheet should contain the airplane model, series, age, number of cycles, tail number, and a summary/description of the accident/ incident causal factors.

8. Using the NTSB Aviation Accident Database, for transport category airplanes, for the period 1983 to present, provide a Microsoft Excel spreadsheet containing each accident or incident involving loss of control/flight control upset . The spreadsheet should contain the airplane model, series, age, number of cycles, tail number, and a summary/description of the accident/ incident causal factors.

9. Using the Airclaims Database, for transport category airplanes, for the period 1970 to present, provide a Microsoft Excel spreadsheet containing each accident or incident involving fire (exclude smoke in the cockpit reports). The spreadsheet should contain the airplane model, series, age, number of cycles, tail number, and a summary/description of the accident/ incident causal factors.

10. Using the Airclaims Database, for transport category airplanes, for the period 1970 to present, provide a Microsoft Excel spreadsheet containing each accident or incident involving loss of control/flight control upset. The spreadsheet should contain the airplane model, series, age, number of cycles, tail number, and a summary/description of the accident/ incident causal factors.

11. Using the Runway Incursion Database, for transport category airplanes, for runway incursions 1985 to present, provide a Microsoft Excel spreadsheet containing each incursion which had mechanical failures as causal factors. The spreadsheet should contain the airplane model, series, age, number of cycles, tail number, and a summary/description of the mechanical failure.

Appendix V: Glossary of Acronyms.

GLOSSARY

AC	Advisory Circular
AD	Airworthiness Directive
AAC	Aviation Advisory Committee
ATA	Airline Transport Association
CAA	Civil Aviation Authorities
DOD	Department of Defense (United States)
FAA	Federal Aviation Administration
HIRF	High Intensity Radiated Fields
HMV	Heavy Maintenance Visit
PMI	Principal Maintenance Inspector
MSG-3	Maintenance Steering Group, Revision 3 process
OEM	Original Equipment Manufacturer
NASDAC	National Safety Data Analysis Center
NASA	National Air and Space Administration
PIREPS	Pilot Reports
RPD	Research Project Description
SAE	Society of Automotive Engineers
SDR	Service Difficulty Report
TAD	Transport Airplane Directorate
WHCSS	White House Commission on Safety & Security

Appendix VI: Major Contributors to the FAA Aging Non-Structural Systems Plan

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