DISPOSITION OF RECOMMENDATIONS PUBLISHED IN

THE "TRANSPORT AIRCRAFT INTRUSIVE INSPECTION PROJECT (An Analysis of the Wire Installations of Six Decommissioned Aircraft) FINAL REPORT" DATED DECEMBER 29, 2000

January 21, 2003

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The FAA wishes to express its gratitude to all the Companies, Organizations, Regulatory Authorities and Individuals who contributed their time and resources to the development of this report.

CHAPTER 1: PURPOSE AND HOW TO USE THIS DOCUMENT

Purpose

The purpose of this report is to provide details of action and implementation plans committed to the FAA as a result of publication of the "Transport Aircraft Intrusive Inspection Project (An Analysis of the Wire Installations of Six Decommissioned Aircraft) Final Report" (Intrusive Inspection Report) dated December 29, 2000. This report is being coordinated and harmonized with the Joint Aviation Authorities (JAA) and Transport Canada.

How to use this document

Use of Hyperlinks

For those readers wishing to use the electronic capabilities of this document, hyperlinks have been provided that allow direct access to selected external web sites and direct navigation to bookmarks or sections, using the forward and reverse arrows. All hyperlinks are underlined and shown in blue.

Selection of Level of Detail

The original Intrusive Inspection Report listed more than 100 recommendations. Since each recommendation generated one or more action plans, some of which were overlapping, the resulting source data generated was considerable. To simplify use of this data, the information in this document is presented at three different levels of detail (see table) described below. Users can select the appropriate level based on their individual needs. A brief history of activities relating to this report is contained in Chapter 3: Background.

LEVEL	DESCRIPTION
1	Executive Summary
2	Summary of Detailed Action Plans
3	Detailed Action Plans

} Solution Matrix

Level 1: Executive Summary (Chapter 2)

The executive summary provides a high level overview of the actions taken following the FAA evaluation of the Intrusive Inspection Report's recommendations. Actions contained in this summary have been organized into some of the categories originally designated by the FAA in the Enhanced Airworthiness Program for Airplane Systems (EAPAS)[1]: Training, Maintenance, Design, and Research and Development.

Level 2: Summary of Detailed Action Plans (Chapter 5)

This level provides an expanded summary of detailed action plans and commitments made in response to the Intrusive Inspection Report recommendations. As in the executive summary, actions contained in this summary have been organized into categories originally designated by the FAA in EAPAS[1]: Training, Maintenance, Design, and Research and Development. Individual recommendations and detailed action plans are linked to these categories (see Level 3 below) using a **Solution Matrix** (Chapter 6).

Level 3: Detailed Action Plans (Chapter 7)

Level 3 provides a complete numbered listing of Intrusive Inspection Report recommendations, the associated action plan to accomplish each recommended action, and the "owner" (e.g., airframe manufacturer, harmonization working group, etc.) responsible for the plan.

[1] See EAPAS Section 3, Page 12, "EAPAS Implementation Plan"

The remainder of the report provides details of the methodology used in reviewing each recommendation (Chapter 4) and detailed data in the form of appendices. Appendices A and B contain source data used in the process. Appendix C contains a matrix of any commitments made by action plan owners that remain open. These open commitments will continue to be tracked by the FAA to ensure timely completion.

CHAPTER 2: EXECUTIVE SUMMARY

Introduction

The "Transport Aircraft Intrusive Inspection Project (An Analysis of the Wire Installations of Six Decommissioned Aircraft) Final Report" (Intrusive Inspection Report) was published December 29, 2000. It lists 107 recommendations for follow-on action. The recommendations are directed to commercial airframe manufacturers, Aging Transport Systems Rulemaking Advisory Committee (ATSRAC) working groups, airlines, and the FAA. These groups were tasked to develop action plans in response. Each recommendation was assigned to one of the individual stakeholders as its "owner."

Following approval by ATSRAC, the FAA conducted a comprehensive review of the action plans developed by the appropriate stakeholders in order to assess their efficacy. The action plans took into account all levels of potential risk and responded to the worst-case scenario. The FAA has concurred with all of the action plans developed by their owners.

A number of commitments made by the action plan owners are still open at the time of publication of this report. To ensure timely closure, the FAA will track these commitments. A matrix of open commitments has been developed and is shown in Appendix C.
A brief history of activities relating to this report is contained in Chapter 3 (Background). Chapter 4 (Methodology) is an explanation of the process used to evaluate the action plans. A summary of the action plans is contained in Chapter 5 (Summary of Intrusive Inspection Report Recommendations and Action Taken). The complete list is contained in Chapter 7 (Detailed Action Plans).

This report is being coordinated and harmonized with the Joint Aviation Authorities (JAA) and Transport Canada.

Summary of Outcomes and Committed Actions

For summary purposes, actions have been separated and sorted into some of the primary categories originally designated by the FAA as part of the Enhanced Airworthiness Program for Airplane Systems (EAPAS): Training, Maintenance, Design, and Research and Development.

This summary does not include those Intrusive Inspection Report recommendations that were satisfied by airframe manufacturer or industry programs or programs that presented an alternate solution.

Training

Training material specified in Appendix B of draft Advisory Circular 120- YY, the product of ATSRAC working Group 8, will contain sections covering wiring inspection, installation, protection, cleaning, use of approved materials, and use of approved commercial airframe manufacturers/FAA practices.

Maintenance

The Enhanced Zonal Analysis Program (EZAP), the product of ATSRAC working group 3, has been developed as a draft Advisory Circular 120-XX by ATSRAC working group 9. The advisory circular provides procedures for EZAP to be applied to all current transport category type certificated aircraft and to all supplemental type certificates (STCs) and all applicable service bulletins (SBs). EZAP has also been incorporated into ATA's Maintenance Steering Group Document 3 (MSG3) Revision 2001.1. EZAP contains processes which develop discrete tasks covering periodic cleaning, general visual inspections, and detailed inspections of wiring (including power feeder cables). EZAP also requires consideration of potential heat sources and combustible material in aircraft zones when developing zonal inspection instructions.

In addition, ATSTRAC working group 9 has developed a draft notice of proposed rulemaking (NPRM) which mandates the performance of EZAP by manufacturers and operators for in-service aircraft. The NPRM also amends the Instructions for Continued Airworthiness criteria, found within the 14 CFR part 25 design

standard for new aircraft, to include scheduled maintenance instructions for electrical wiring interconnection systems derived from the application of an analytical logic procedure, protection and caution information, electrical wire interconnection system practices in a standard format, and electrical load data and instructions for updating the electrical load data.

Wiring Manuals

A draft advisory circular, “Development of Electrical Systems Wiring Practices Documentation,” the product of ATSRAC working group 7, has been developed. The draft advisory provides guidance for developing an electrical system standard wiring practices document for air carriers, air operators, holders of type certificates or STCs, maintenance providers, and repair stations.

The three participating airframe manufacturers (Airbus Industrie, Boeing Commercial Airplane Company, and Lockheed Martin Corporation) have committed to revising their standard wiring practices manuals. The changes will include specifications for heat shield or drip shield installation, proper cleaning practices, and best practices for maintenance of power feeder cables. Airbus Industrie, Boeing Commercial Airplane Company, and Lockheed Martin Corporation will also include cautionary notes in their service bulletins regarding the importantance of protecting wiring during maintenance.

Design

New rules have been drafted under the proposed subpart H of 14 CFR part 25, the product of ATSRAC working group 6. Corresponding advisory material, in the form of a new advisory circular (AC) for domestic and foreign manufacturers about electrical wiring interconnection systems, has been prepared. In addition to organizing all wire related certification requirements into the proposed subpart H, the new and revised certification rules and advisory material addresses multiple wire related design and maintenance issues. These include among other, wire separation and segregation, updated wire splicing practices, wire selection, wire identification, wire system safety assessments, and maintenance practices (in the form of continued instructions for airworthiness).

The three participating airframe manufacturers (Airbus Industrie, Boeing Commercial Airplane Company and Lockheed Martin Corporation) have committed to including in their standard wiring practices manuals a recommendation that operators document the location of repair splices for future reference. Additionally, Airbus Industrie, Boeing Commercial Airplane Company, and Lockheed Martin Corporation are now requiring, or will soon require that, throughout the airplane, only environmental splices be used in production.

Research and Development

The FAA has active research and development programs in place that address all the general recommendations made in the Intrusive Inspection Report. The three participating airframe manufacturers (Airbus Industrie, Boeing Commercial Airplane Company, and Lockheed Martin Corporation) also have active programs to pursue both development of arc fault circuit breakers and use of non-destructive testing to troubleshoot wire installations.

CHAPTER 3: BACKGROUND

In July of 1999, the Aging Transport Systems Rulemaking Advisory Committee (ATSRAC) and the FAA sponsored the Intrusive Inspection Working Group. This working group came under the aegis of the FAA's Aging Non-Structural Systems Plan announced in October 1998[2]. Its objective was to collect essential wire degradation data for the Aging Civil Fleet Program, a program that had not been a part of the non-intrusive inspections accomplished earlier[3]. The working group was led by Dr. Chris Smith of the FAA Technical Center and consisted of an international team of wiring experts representing a broad spectrum of the aviation industry (commercial, aerospace, and military[4]). The working group published its final report on December 29, 2000, "The Transport Aircraft Intrusive Inspection Project (An Analysis of the Wire Installations of Six Decommissioned Aircraft)."

A key element of the report was over 100 detailed conclusions and recommendations for follow-on action (see Appendix B). These recommendations were directed to commercial airframe manufacturers, ATSRAC working groups, airlines, and the FAA. The recommendations were organized into six components (deteriorated repair, heat damage or burnt wire, vibration damage/chafing, cracked insulation, arcing, and delamination) and numerous elements, each element including an assessment of its potential safety impact. General recommendations were also made for additional research and development activities.

ATSRAC carefully reviewed and approved this report and agreed on a plan to act upon its recommendations. Each recommendation was assigned an "owner," responsible for its follow-through. Each owner was required to develop an action plan. The FAA conducted a comprehensive review of all the action and implementation plans with the appropriate stakeholders in order to assess their efficacy. Since ATSRAC was required to ensure that Harmonization Working Groups 6, 7, 8, and 9 had adequately addressed recommendations made in the report, ATSRAC also implemented a separate review process to satisfy this objective. These processes are described in detail under Chapter 4: Methodology.

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[2] FAA Orders 1110.127 and 1110.127A

[3] "Transport Aircraft Intrusive Inspection Project (An Analysis of the Wire Installations of Six Decommissioned Aircraft) Final Report," dated December 29, 2000, Chapter 1 and Appendix 1.1

[4] "Transport Aircraft Intrusive Inspection Project (An Analysis of the Wire Installations of Six Decommissioned Aircraft) Final Report," dated December 29, 2000, "Transport Aircraft Intrusive Inspection Project"

To ensure continuity and ease of comparison, some data contained in this report has been extracted directly from the "Transport Aircraft Intrusive Inspection Project (An Analysis of the Wire Installations of Six Decommissioned Aircraft) Final Report" dated December 29, 2000[5].

[5] "Transport Aircraft Intrusive Inspection Project (An Analysis of the Wire Installations of Six Decommissioned Aircraft) Final Report," dated December 29, 2000, Chapter 7, Table 7

CHAPTER 4: METHODOLOGY

Introduction

During the October 2001 ATSRAC meeting, ATSRAC and the FAA decided to establish a process for addressing recommendations made in the "Transport Aircraft Intrusive Inspection Project (An Analysis of the Wire Installations of Six Decommissioned Aircraft) Final Report" (Intrusive Inspection Report).

For each recommendation, it was decided that:

(a) An "owner" must be assigned.
(b) Each owner must develop an action plan.
(c) ATSRAC (and the public) would comment on each action plan.
(d) The FAA would review the action plan to determine its efficacy.

ATSRAC also decided that status reports would be presented at formal ATSRAC meetings. Regular interim reports would be transmitted by e-mail on a bi-weekly basis, and would contain any issues requiring the committee's attention.

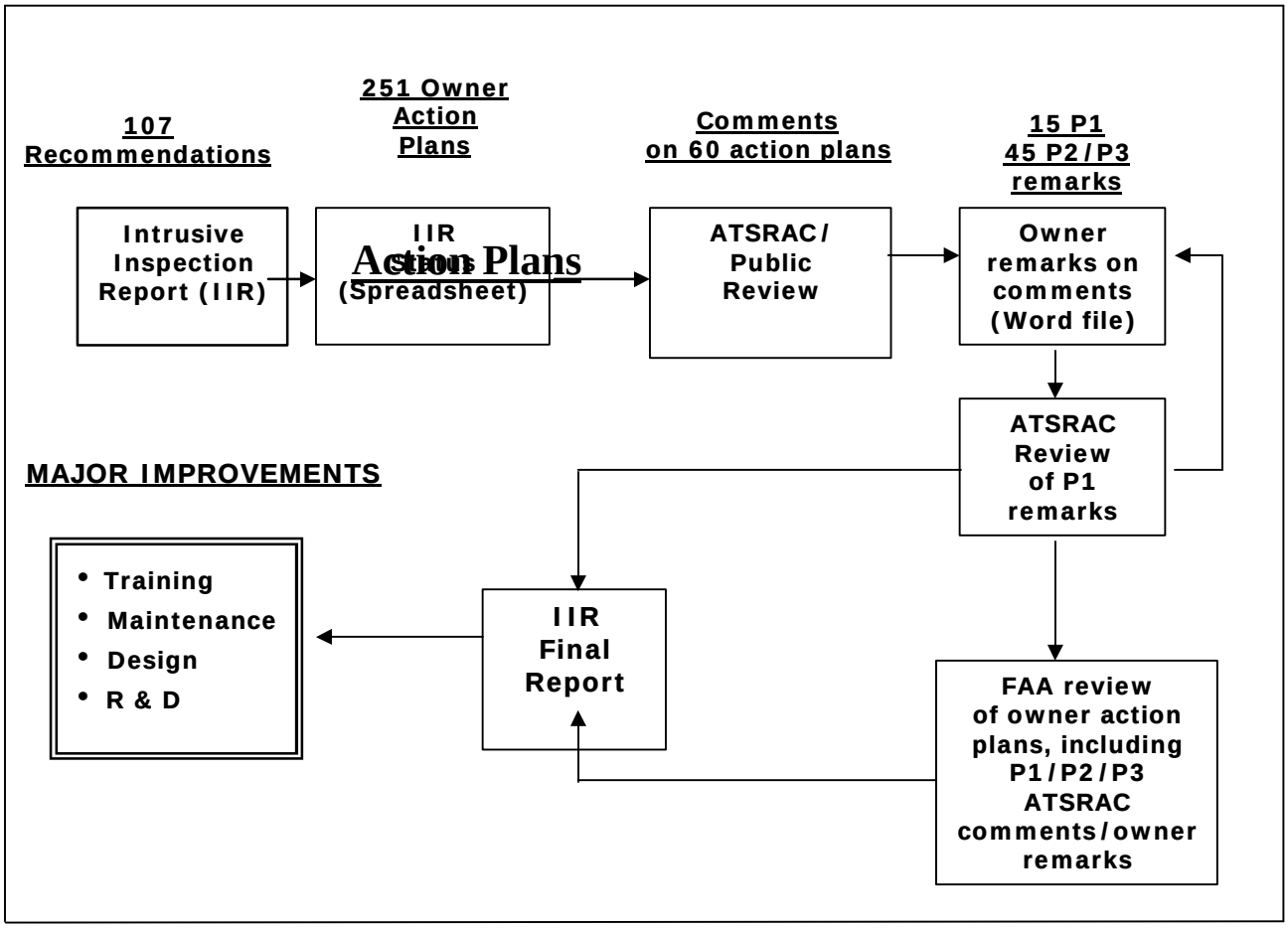
Responsibility

ATSRAC was required to ensure that harmonization working groups (Working Groups 6,7,8, and 9) adequately addressed the relevant Intrusive Inspection Report recommendations in their final reports. The FAA is responsible for determining that all recommendations were adequately addressed.

A block diagram (Figure 1) of the review process is shown below and described in detail in the remainder of this chapter.

Figure 1

Action Plan Review Process

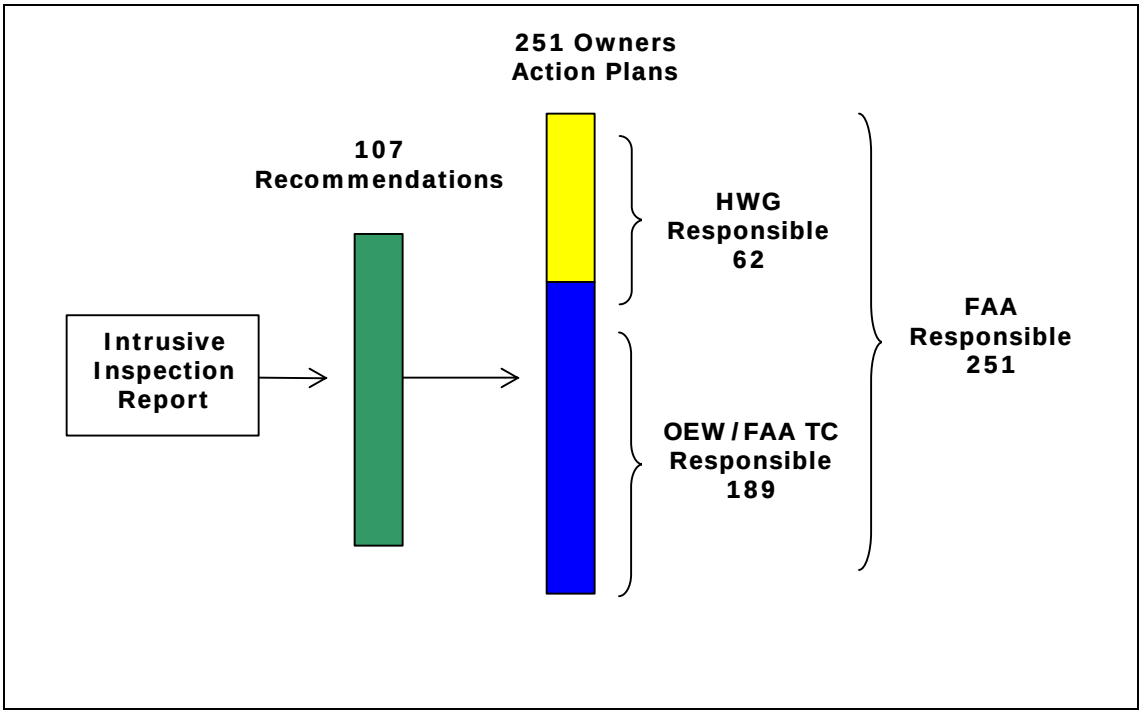


Recommendations made in the Intrusive Inspection Report were entered into a single spreadsheet.

Although there were 107 basic recommendations, many of them had to be separated into multiple components before owners could be assigned. As a result, a total of 251 recommendations were identified. The owners assigned to develop action plans for these recommendations were ATSRAC Harmonization Working Groups (HWG) 6, 7, 8, and 9, the three participating airframe manufacturers (Airbus Industrie, Boeing Commercial Airplanes and Lockheed Martin Corporation), and the FAA.

Of the 251 action plans identified, 62 were assigned to HWGs. The remainder (189) were assigned to the three participating airframe manufacturers (Airbus Industrie, Boeing Commercial Airplane Company, and Lockheed Martin Corporation) and the FAA Technical Center (see Figure 2 below).

Figure 2



To track the progress of the action plans, "stoplights" indicating project status (red, yellow, and green) were added to the spreadsheet, based on the following protocol:

- Red – unable to meet the plan and schedule
- Yellow – not on plan but recovery plan in place and able to meet schedule
- Green – on plan and schedule

Owners were asked to develop an overview of each action plan, together with an assessment of their individual "stoplights." This package was presented to ATSRAC and the FAA during their regular meeting in January 2001 in Atlanta, GA. At this meeting, ATSRAC members, the FAA, and the public were asked to provide comments on the action plans. It was further agreed that comments received would

then be compiled, combined with responses from individual owners, and reviewed again at the next regular ATSRAC meeting in Phoenix, AZ, in April 2002.

A total of 60 comments were received. These comments were compiled into a document entitled "Intrusive Inspection Recommendations~ Comments on Owner Incorporation Plans" (see Appendix A) and categorized into those directly relating to HWG 6, 7, 8, or 9, identified as priority 1 (P1) items, and those relating to the three participating airframe manufacturers (Airbus Industrie, Boeing Commercial Airplane Company, and Lockheed Martin Corporation) or the FAA Technical Center, designated as priority 2 (P2/P3) items. There were 15 P1 comments and 45 P1/P2 comments.

Since only P1 comments were the responsibility of ATSRAC, they were reviewed at its meeting in Phoenix. Additional comments were made by ATSRAC and the public at that meeting, and affected owners agreed to incorporate those comments into the revised document of Appendix A. Copies of the P2/P3 comments and revised owner responses to P1 category comments were subsequently provided to ATSRAC members for information purposes.

The FAA agreed to review the remaining P2/P3 action plans with the affected manufacturers and provide an FAA position to ATSRAC. The agency subsequently carried out extensive reviews with technical representatives of the three participating airframe manufacturers (Airbus Industrie, Boeing Commercial Airplane Company, and Lockheed Martin Corporation), and revisions were made. The revised document containing updated comments was sent to ATSRAC members on June 4, 2002 and is shown in Appendix A.

Following its review of the P2/P3 action plans, the FAA conducted a detailed review of all action plans with Airbus Industrie's, Boeing Commercial Airplane Company's, and Lockheed Martin Corporation's technical representatives. This review included (a) developing action plans common to the three airframe manufacturers where appropriate, and (b) incorporating comments from ATSRAC members as described above. Action plans were revised if necessary. A complete listing of these action plans was then incorporated into the spreadsheet and is shown in Chapter 7. The FAA concurs with these plans.

Follow-up

A number of commitments by action plan owners are still open at the date of this report. To ensure timely closure, the FAA will track these

commitments. A matrix of open commitments has been developed and is shown in Appendix C.

CHAPTER 5: SUMMARY OF INTRUSIVE INSPECTION REPORT RECOMMENDATIONS AND ACTION TAKEN

The following is a summary of recommendations extracted from Chapter 7 of the Intrusive Inspection Final Report dated December 29, 2000. These recommendations, which are shown in **bold** type, have been categorized into five main sections; Training, Maintenance, Design, Research and Development, and Other. These are similar to those shown in the FAA EAPAS implementation plan. Each recommendation is followed immediately by a summary of the relevant action plan (unbolded) as developed either by the appropriate ATSRAC Harmonization Working Group(s), and/or the participating airframe manufacturers (Airbus Industrie, Boeing Commercial Airplanes, and Lockheed Martin Corporation).

TRAINING

Inspection

Seven recommendations were made in five categories relating to providing training for wire inspection. Except for #5, all recommendations are covered in draft Advisory Circular 120 - YY, (Aircraft Systems Training Program) dated 3/21/02, Appendix B, Curriculum and Lesson Plan, as indicated below:

1 Use of proper maintenance techniques to identify suspect wires

This is covered in Appendix B Module E 5 and E 6

2 Awareness training for maintenance personnel on the dangers of arcing

This is covered in Appendix B Module E 2c

3 Additional precautions to be used when performing maintenance in the cockpit and electronics bay

This is covered in Appendix B Module C3 and D2/3

4 Inspection of wire splices for signs of obvious deterioration, improper splice installation, and use of approved materials

This is covered in Appendix B Module C4 and E 6

5 Proficiency training practices for splice installation to ensure full awareness of approved materials

The operator's Principal Maintenance Inspector will determine any requirements for initial and proficiency training of splicing using hands-on practices.

Installation

Four recommendations were made in three categories relating to training covering wire installation. Except for #3, all recommendations are covered in draft Advisory Circular 120 - YY, (Aircraft Systems Training Program) dated 3/21/02, Appendix B, Curriculum and Lesson Plan as indicated below:

1 Use of proper approved OEM/FAA practices for wire bundle separation/segregation, use of tie downs, particularly in high vibration areas and/or where wires or cables cross or come in contact

This is covered in Appendix B Module E4

2 Use of guidelines to ensure that all maintenance personnel, not just electrical maintenance technicians, are made aware of those actions that could result in breached wire. Small breaches (such as those resulting from the needling of wire) should not be dismissed as inconsequential.

This is covered in Appendix B Module B3

3 Proficiency training practices for splice installation to ensure full awareness of approved materials

The operator's Principal Maintenance Inspector will determine any requirements for initial and proficiency training of splicing material.

Cleaning

It was recommended that situation-specific guidance be developed and training provided to ensure proper attention is being made to protection and cleaning of wire bundles.

This recommendation is covered in draft Advisory Circular 120 - YY, (Aircraft Systems Training Program) dated 3/21/02, Appendix B, Curriculum and Lesson Plan under Appendix B Module D4

MAINTENANCE

Inspection

Six recommendations were made that periodic, selective inspection and nondestructive testing of wiring in areas exposed to contamination be investigated, with focus on cockpit and electronics bay including those areas supporting multiple flight critical systems.

MSG3 Rev 2001.1 Enhanced Zonal Analysis Program (EZAP) logic requires consideration of the presence of combustible materials in a zone, and identification of tasks to remove significant accumulations of combustible contamination. In addition, enhancements to maintenance practices are proposed that will minimize the risk of damage and contamination to wiring caused by maintenance activity**.**

Manufacturers presently conduct periodic inspections of airplanes, including the cockpit and electronics bay. The information collected as a result of these inspections is used to improve and update, as required, the current electrical design, technology of electrical components and technical design directives. It is their position that these ongoing assessments, in addition to the enhanced zonal inspections emanating from the EZAP, should result in an increased frequency and intensity of inspection.

Two recommendations were made for more detailed inspection and testing of power feeder cables to ensure potential chafing problems are identified and corrected.

MSG3 Rev 2001.1 EZAP logic includes a section entitled "Details of Zone", where installed equipment, wire bundles, possible combustible materials present, Lightning/High Intensity Radiated Field (L/HIRF) protection features, etc., are determined as a prerequisite to conducting a zonal analysis. Due to their high current potential and ease of identification (size), presence of feeder cables will be specifically noted in the list of details in a zone and considered for detailed inspection based on zone environment and frequency of maintenance access to the zone where potential damage could occur.

It was recommended the MSG3 process be modified to include consideration of potential heat sources when developing zonal inspection instructions.

MSG3 Rev 2001.1 EZAP logic requires assessment of environment in the selection of wiring system tasks and intervals. Presence of a heat source or other conditions deemed hostile to wiring will be considered in the selection of tasks and intervals for inspection of wiring in the zone(s).

It was recommended that visual indications be provided to more precisely characterize symptoms of wiring degraded by heat or contaminants, such as high pH.

Guidance for these conditions will be included in the recommended content of FAA Advisory Circular 120-XX

Manufacturer guidelines for cleaning of and conditional inspection for contaminated, overheated or damaged wiring is either included, or will be included in the appropriate maintenance documentation. Manufacturers account for the environment in which wiring is expected to operate and specify wiring and components suitable for that environment. It is their position that these guidelines, together with the additional guidance material to be contained in the proposed Advisory Circular precludes the need to install additional in situ indicators.

Installation

Five recommendations were made that heat or drip shield installation and maintenance are appropriately specified.

Manufacturers will revise the appropriate standard practices wiring manuals to emphasize the importance of proper installation and maintenance of all heat and drip shields to ensure the continued reliability of electrical wiring.

It was recommended that the use of nondestructive testing to troubleshoot suspect wire installations be investigated.

The use of general and detailed visual inspections of wiring installed in airplanes presently remains the preferred method of detecting actual or the potential for damage to wiring. This preference accounts for the present level of diagnostic equipment available to the industry, the needs of the industry, and the potential for undetected damage to result in failure. The manufacturers and FAA will continue to consider non-destructive test (NDT) methods other than visual inspections as a

method of identifying actual or potential wiring faults. However, the use of NDT is insufficiently mature to apply on a scheduled basis at this time.

It was recommended that operators be made aware of best practices for electrical power feeder cables.

Proper installation and maintenance of electrical power feeder cables will be included in the standard wiring practices manuals as minimum content. It is also included in Advisory Circular 120-YY as part of the required maintenance-training program.

It was recommended that best practices be developed regarding the maximum number of splices permitted for various types of circuits based upon frequency and severity of potential splice failures.

Airbus and Boeing presently specify in their standard wiring practices manuals the maximum number of splices permissible per wire run (3). Lockheed design requirements specify the maximum number of splices permissible per wire run (3), and will incorporate this data into the revision of their standard wiring practices manual.

Cleaning/Contamination

Seven recommendations were made that situation-specific guidance be developed to ensure proper attention be given to cleaning of wire bundles.

General and conditional wiring cleaning procedures will be included in the manufacturers standard wiring practices manuals as minimum content. The manufacturers will specify general guidelines concerning wiring cleaning procedures. In addition, enhancements to maintenance practices will be required that minimizes the risk of damage and contamination to wiring caused by maintenance activity. EZAP requires consideration of the presence of combustible materials in a zone, and identification of tasks to remove significant accumulations of combustible contamination.

Non-Destructive Testing

Sixteen recommendations were made that periodic, selective non-destructive testing (NDT) of wiring should be investigated, with particular focus on the cockpit, electrical and electronic bay areas, and those wire bundles supporting multiple flight critical systems.

Currently available NDT methods are provided within the specific airplane maintenance manual chapters appropriate for the system-undergoing test.

General and detailed inspections of wiring installation in airplanes are the normal methods of detecting actual or potential damage to wiring, because these types of inspections are presently more practicable than NDT.

Manufacturers and the FAA are presently evaluating the use of new NDT diagnostic equipment utilizing various technologies to identify actual or the potential for wiring faults.

It was recommended that guidelines be specified that precipitate nondestructive testing or an invasive inspection of wire bundles exposed to suspected high or low pH contaminants, including guidelines for decontamination procedures for wire to neutralize the effects of chemically aggressive contaminants.

Guidance for these conditions will be included in the recommended content of FAA Advisory Circular 120-XX.

Manufacturers account for the environment in which wiring is expected to operate and specify wiring and components suitable for that environment. Manufacturer guidelines for cleaning of and conditional inspection for contaminated, overheated or damaged wiring are either included, or will be included in the appropriate maintenance documentation. Although they do not assess the acidity or alkalinity of contaminants, present guidelines regarding the cleaning and/or repair of wiring account for the wide pH range of possible contaminants.

DESIGN

Wiring Design (Airbus Industrie, Boeing Commercial Airplane Company, and Lockheed Martin Corporation)

Four recommendations were made that wire splicing practices be updated as required in three areas, specifically:

(a) Tag splice locations to aid in future visual inspections
(b) Eliminate the need for splices, including splice versus wire replacement guidelines
(c) Give special consideration to proximity of splice to non-fire retardant materials and expected wire current, with emphasis on multiple flight critical systems

General - Recommendations regarding the use of splices are provided in the manufacturers standard wiring practices manuals.

(a) Tagging or physical identification of the splice location is not presently a recommended practice. Due to the nature of the splice installation practices, a repair splice is usually placed on the outside of the wire bundle where it is visible for conditional inspection. The system in which the wire applies may be determined by verifying the wire number, and the system to which the wire applies can be verified by consulting the Wiring Diagram Manual. Some manufacturers specify the system directly on the wiring. However, manufacturers will include within their standard wiring practices manuals recommendations that operators record within their documentation the location of repair splices for future reference.

(b) The use of splices is a necessary and effective method of branching systems during airplane manufacture. Although wire replacement rather than repair is preferred, the nature of wire routing throughout the airframe, the reduced reliability associated with wiring designs with an increased number of connectors, and the limited access to all individual wires, necessitates the use of splices for repair. However manufacturers support the reduction in the number of splices wherever possible. The specification of which type of manufacturing splice is used in each situation is reflected within the manufacturers standard wiring practices documents, i.e. what is accomplished during production is permitted on in-service airplanes. In addition, the OEMs have already or will soon begin to require the use of only environmental splices for repairs of wiring during production in all locations of the airplane.

(c) Splices are specified in the wiring design based upon the wire size, a direct result of the load on the circuit. As the fire-retardancy properties of adjacent materials is not normally known during the design or repair of the electrical system, manufacturers consider this recommendation as impractical. Typically the most restrictive condition within a zone, such as the presence of fuel vapor, is used to assess the splice type and installation technique, rather than assess the type and proximity of all adjacent materials within a wiring run. However, manufacturers will consider any forthcoming recommendations regarding improvements in splicing practices to prevent the potential for high resistance heating in the presence of flammable materials and high-current applications

adjacent to or within wire bundles containing flight-critical systems.

Twelve recommendations were made that design and maintenance practices be reviewed regarding minimizing the potential for contamination, including the use of heat and drip shields, together with establishing on-condition criteria for the replacement of wire in heat-damaged bundles (external and internal heat).

Expected and actual sources of contamination (e.g. heat and moisture impinging on electrical wiring) are presently taken into consideration during the design of the electrical system in the form of heat or drip shields. Manufacturers' heat and moisture protection guidelines used in the design of the wiring systems indicates that this information is of a general nature, accounting for the wiring environment, the type of wiring specified for use in the area, and installation details. Inclusion of this information within the Electrical Standard Wiring Practices Manual is not practical. When unanticipated sources of contamination are identified during service operation, additional protection is specified and available to operators through a service letter or service bulletin. In the case of general protection of wiring during unrelated maintenance, manufacturers will provide protection guidelines in future revisions to their Standard Wiring Practices Manuals.

Allowable wire damage criteria are already specified in the appropriate manufacturers standard wiring practices manuals. Additional wiring protection is provided in locations where in service experience dictates that protection is needed. Operators are expected to identify areas of heat or moisture damaged wiring during normal maintenance activities and take appropriate action. In addition, the FAA has written to all US TC and STC holders requesting them to implement notes in all service bulletins cautioning operators about the importance of protecting wiring during maintenance.

Six recommendations were made that separation and segregation guidelines be developed and/or updated with particular focus on:

(a) Loss of multiple critical functions from a common mode failure in areas containing non-fire-retardant materials
(b) Areas containing power feeder cables

Manufacturers wire separation and segregation guidelines are presently contained within their standard wiring practices manuals and reflect current production design standards that account for loss of multiple or redundant systems. These standards apply to all zones and all materials. Any changes to the standards will be reflected in

future revisions to the above document. In the case of power feeder cable routing, separation and attachment guidelines unique to airplane power feeder cables is presently available in the Airbus and Boeing standard wiring practices manuals. The Lockheed standard wiring practices manual currently provides wire bundle maintenance guidelines but does not specifically provide guidelines for power feeder cables. Lockheed will develop specific maintenance practices for power feeder cables and incorporate them into their standard wiring practices manual at the next revision.

Three recommendations were made that manufacturers review design practices regarding the clamping and tying of wire bundles.

Manufacturers have conducted a review of wire clamping and bundle assembly techniques. This review is now complete with no changes deemed necessary.

Release of an SFAR requiring that the standard wiring practices manual be included as part of the Instructions for Continued Airworthiness (FAR 25-1529, Appendix H) will ensure that operators will be using the guidelines outlined within that document, or use equivalent procedures developed using their own expertise. These standard wiring practices manual guidelines specify proper wire installation requirements

Ten recommendations were made that manufacturers specify accelerated removal of flammable materials, with focus on the flight deck and electrical and electronics bay. One recommendation was made to consider a local design modification to replace non-fire retardant materials.

Use of the term "flammable materials" refers to the accumulation of contaminants over time rather than an assessment of the flammability of the materials used in the construction of the airplane. Effective procedures for removal of flammable contaminants are specified in the manufacturers' standard wiring practices manuals.

With respect to elimination for non-fire retardant materials, specification and use of materials in the manufacture of an airplane, especially the ability of the material to self-extinguish, comply with federal regulations at the time of certification. Service experience or a change in the use of the airplane would be used to determine whether an original material should be replaced by a material meeting a different fire retardancy standard.

Manufacturers support the timely removal of flammable contaminants and recommend that operators do so. However, they do not support the identification and removal of materials that meet fire retardancy requirements and which do not degrade the operational safety of the airplane. There are several ongoing studies aimed at reducing or eliminating the use of non-fire retardant materials in the flight deck and E/E bay areas, one of which is an ARAC. The manufacturers will actively participate in these studies in order to identify acceptable materials, and will consider use of these materials in present and future airplanes.

Certification/Compliance

Thirteen recommendations were made that separation and segregation guidelines should be reviewed, with respect to:

(a) Loss of multiple critical functions from a common mode failure
(b) Power feeder cables
(c) Wires with known arc tracking potential
(d) Separation of wire bundles from non fire retardant material

HWG6 has drafted new rules under the proposed Part 25, Subpart H. Proposed rules 25.1701, 25.1703, 25.1705, 25,1709, and 25.1711, together with corresponding Advisory Material in the new AC/ACJ for electrical wiring interconnect systems (EWIS) for these conditions, to provide the necessary guidelines. (See HWG6 Final Report Appendices A, B, and D).

Three recommendations were made to update wire splicing practices relating to (a) use of environmental splices in SWAMP/non-SWAMP areas, (b) proximity to non fire retardant materials and (c) expected wire current.

HWG6 has drafted Advisory Material in the new AC/ACJ for EWIS, for these conditions to provide the necessary guidelines. (See HWG6 Final Report Appendices B and D).

Seven recommendations were made that design modifications be made to minimize potential for contamination, including proper protection and cleaning of wire bundles.

HWG6 has drafted new rules under the proposed Part 25, Subpart H. Proposed rules 25.1703, 25.1705, and 25.1709,

together with corresponding Advisory Material in the new AC/ACJ for EWIS for these conditions, provide the necessary guidelines. (See HWG6 Final Report Appendices A, B, and D).

It was recommended that design and maintenance practices be reviewed regarding the use of heat shields, including criteria for replacement of heat damaged wire bundles.

HWG6 has drafted new rules under the proposed Part 25, Subpart H. Proposed rules 25.1705 and 25,1709 together with corresponding Advisory Material in the new AC/ACJ for EWIS for these conditions provide the necessary guidelines. (See HWG6 Final Report Appendices A, B, and D).

It was recommended that flammable material be removed from the cockpit and E & E bay

The intent of this recommendation was directed primarily toward removal of metalized Mylar insulation. An airworthiness directive has been issued covering removal of this material.

RESEARCH AND DEVELOPMENT

Installation

Two recommendations were made that non-destructive testing be investigated to troubleshoot suspect wire installations.

Manufacturers and the FAA are presently evaluating the use of diagnostic equipment utilizing various technologies to identify actual or the potential for wiring faults.

Two recommendations were made that separation and segregation of wires installed after manufacture of the aircraft be investigated

The FAA has awarded a research contract to Raytheon Technical Services Company (RTSC) to assess requirements for separation and segregation. RTSC will conduct testing as part of this assessment.

Cleaning / Contamination

Two recommendations were made that sources of potential contamination and their effects on wire degradation be analyzed

The FAA is currently conducting a three-year program that will address this condition. Phase I of the project is now complete A contract to complete Phase II (Testing) and Phase III (Analysis of Test Results) has been awarded to Raytheon Technical Services Company (RTSC). RTSC, Brookhaven National Labs, Sandia National Labs, and Lectromec will conduct extensive wire testing in support of this project.

Non-destructive Testing

Nine recommendations were made that the FAA/Manufacturers should aggressively pursue development/promotion of arc fault breakers, including retrofit plans onto in service aircraft

Both the FAA and Manufacturers are aggressively pursuing development of arc fault circuit breakers. Manufacturers will evaluate implementation of any new technology such as this, as it is being developed with the input of Operators.

It was recommended that the FAA should aggressively pursue and promote the develop development of non-destructive test equipment for wiring

The FAA is currently conducting research on non-destructive inspection (NDI) and non-destructive test (NDT) methods for the inspection of the EWIS system. Results of the NDI/NDT program will be publicly disseminated.

Additionally, Manufacturers are actively either developing or evaluating wiring test equipment intended to determine the condition of wiring, including cracks and presence of high resistance interconnects.

It was recommended that the FAA should investigate the potential hazards associated with breached wires that are wet and contain non-environmental splices.

This issue is or will be looked at via several avenues of the FAA research program. Mitigation of this hazard is accomplished with the use of AFCB technology. The hazard will also be explored as part of the program to develop advanced risk assessment tools for aircraft electrical systems. The FAA is also pursuing research of advanced risk assessment tools for the EWIS system. In addition to researching potential risk assessment techniques, this project is also monitoring

WG6 activities in this area (25.1705) and considering this in the research program.

It was recommended that the FAA research the effects of thermal damage to wire hot enough to hazard the aircraft.

The FAA will review service data to establish the scope of the problem and the necessity and/or scope of follow-on activity

It was recommended that specific nondestructive testing protocols be establish for power feeder cables.

The FAA is currently conducting research on non-destructive inspection (NDI) and non-destructive test (NDT) methods for the inspection of the EWIS system. All validation efforts will include (as applicable) test and evaluation of the NDI/NDT technique on power feeders. Results of the NDI/NDT program will be publicly disseminated.

4. Wire Degradation

It was recommended that the FAA fully support the wire degradation program, and include the effects of wire to wire chafing as well as the impact of how vibration (solid and liquid) interact.

The FAA is currently conducting a three-year program that will address this condition. Phase I of the project is now complete A contract to complete Phase II (Testing) and Phase III (Analysis of Test Results) has been awarded to Raytheon Technical Services Company (RTSC). RTSC, Brookhaven National Labs, Sandia National Labs, and Lectromech will conduct extensive wire testing in support of this project.

Aging of electrical interconnect components

Three recommendations were made that the FAA should investigate the physical and functional integrity of any electrical system component whose failure could hazard the aircraft, e.g. circuit breakers.

The assessment of aging circuit breaker performance has been completed. Performance assessment of other aging EWIS components will begin in 2003 pending availability of adequate funds for this effort.

OTHER

Configuration Management

It was recommended that manufacturers develop wiring configuration software that will (a) track the installation and location of splices (b) prevent load creep that may result in circuits operating near the rated capacity and conductor heating.

(a) Manufacturers believe that should a tracking procedure be deemed beneficial, the method of identifying, recording, or tracking repair splices on in-service airplanes should be assessed by the individual operator based upon their knowledge of each airplane configuration. However, manufacturers will include within their standard wiring practices manuals recommendations that operators record within their documentation the location of repair splices for future reference.

(b) Manufacturers believe that managing changes to the airplane electrical system, including ensuring that appropriate system capacity is not exceeded, is the responsibility of the owner/operator based upon their knowledge of each airplane configuration. Electrical load documents are provided to operators by all OEM's with the delivery of new airplanes and may be used to manage changes to the electrical systems.

It was recommended that manufacturers develop a catalog of unacceptable wire bundle configurations.

Manufacturers currently have no plans to create a readily accessible electronic library of unacceptable wire bundle configurations. As much of this data already exists with documentation readily available to the operator or repair station, such as ATA Specification 117 and AC 120-YY, manufacturers will provide on request representative photographs or line drawings of unacceptable wire bundle configurations for training purposes.

CHAPTER 6: SOLUTION MATRIX

The original Intrusive Inspection Report recommendations were organized into six major categories (deteriorated repair, heat damage or burnt wire, vibration damage/chafing, cracked insulation, arcing, and delamination) and numerous sub categories. Each sub category was assigned a subjective level of potential risk. As a result there were a considerable number of duplicate recommendations.

For summary purposes actions have been separated and sorted into primary categories originally designated by the FAA as part of the EAPAS[6], for example Training, Maintenance, Design, and Research and Development. For further clarification each primary category was separated into sub categories as relevant:

(a) Inspection
(b) Installation
(c) Cleaning/Contamination
(d) Non destructive testing
(e) Wiring design (manufacturers)
(f) Certification/Compliance
(g) Wire degradation
(h) Aging of electrical interconnect components

To show the relationship between individual recommendations/owner action plans and the categories described above, a solution matrix was developed and is shown below in Tables 1 thru 5. Each numbered action plan shown is hyperlinked directly to detailed information in Chapter 7.

Table 1

[6] See EAPAS Section 3, Page 12, "EAPAS Implementation Plan"

TRAINING	OWNER ACTION PLANS					
1. Inspection	1.2	1.4	3.5(a)	6.3(b)	6c2	GR1
2. Installation	2f3	3.3	6.1	1.4		
3. Cleaning/Contamination	3a1(a)	3b1(a)	2d2			

Table 2

MAINTENANCE	OWNER ACTION PLANS					
1. Inspection	2.1	2.3	2a1	2a2	2a3	2b1
	2b3	2b4(a)	3.1	3g1	5.4(a)	
2. Installation	1.5(c)	2.2	2.5	2b2	2c1	2d2
	3a1(a)	3g3				
3. Cleaning/Contamination	3a1(a)	3a2(a)	3b1(a)	3b2(a)	3c1(a)	3e1
	4e1	6c2				
4. Non destructive testing	2.6	2a1	2a2	2a3	2b1	2b3
	2b4	2c2	2d3	2e3	2f4	2f5(a)
	3a2(b)	3c2(c)	3g1	5.1		

Table 3

DESIGN	OWNER ACTION PLANS					
1. Wiring design (airframe manufactures)	1.1	1.3	1a1	2.4	2b3	2c2
	2d3	2f2	2f4	2e2	3a3	3b1(b)
	3b2(b)	3b3	3c2(a)	3e2	3g2b	4a1
	4a2	4b1	4b2	4b4	4c1	4c2
	4d1	4e1	4e2	4f1	4f2	5a1
	5a2	6a1	6b1	6c1	6d1	
2. Certification/Compliance	1.1	1.5(a)	1a1	2.4	2b4b)	2d4
	2e2	2f2	3a1(b)	3a3	3b1(b	3c2(b)
	3d1	3e2	3f1	3g2(b)	4a3	4b3
	4d1	4e1	5.4(b)	6c1	6d2	6e1

Table 4

RESEARCH AND DEVELOPMENT	OWNER ACTION PLANS					
1. Installation	2e3	2e4(a)	2f4(b)	2f5(b)		
2. Cleaning/Contamination	2e4	GR4				
3. Non destructive testing	2.6	3.4	3.5(b)	3g2(a)	4.1	4.2
	4.3	5.2	6.2	6.3(a)	6.4	GR5
	GR6	GR7	GR10	GR11		
4. Wire degradation	3b4	3e3	GR2	GR3		
5. Aging of electrical interconnect components	GR8	GR9	GR10			

Table 5

OTHER	OWNER ACTION PLANS					
1. Configuration management	1.5(b)					
2. Database of unacceptable wire bundle configurations	2.4	3.2				

CHAPTER 7: DETAILED ACTION PLANS

Revision	Date	Revision Highlights
Original issue	01/16/02	Original issue presented to ATSRAC in Atlanta January 24, 2002
R1	03/01/02	Adds incorporation plans from Airbus and Lockheed
R2	03/12/02	Adds updated incorporation plans from the FAA, additional comments from Lockheed and catalogs comments made by ATSRAC members on owners plans
R3	03/19/02	Adds updated incorporation plans from Airbus, and additional Boeing supplemental responses
R4	05/23/02	Revises owner plans affecting HWG's, as appropriate, based on (a) ATSRAC review in Phoenix, April 24, 2002 and (b) FAA review of OEM/FAA owner plans receiving comments from ATSRAC/non ATSRAC members
R5	06/06/02	Revises owner plans and consolidates OEM action plans as appropriate for those items, which received no comments from ATSRAC/non ATSRAC members. Adds space for FAA comments
R6	07/02/02	Eliminates stoplights, adds solution matrix and summary sections
R7	07/26/02	Revises solution matrix and summary sections
R8	09/25/02	Revises solution matrix and summary sections
R9	10/04/02	Revises detailed action plans and summary sections, based on FAA review, October 2 thru 4 2002
R10	10/26/02	Updates detailed action plans and summary sections, based on status provided by the FAA Tech Center

During the January 2002 ATSRAC meeting held in Atlanta, GA, members were asked to provide detailed comments by February 20, 2002, on owner's incorporation plans for each of the recommendations made.

5 ASRAC and 2 non-ATSRAC members subsequently submitted comments. Items commented on were as follows:

1.1, 1.3, 1.5,1.5b, 1a1, 1b1

2.4, 2.6, 2a2, 2a3, 2b3, 2b4, 2c1, 2c2, 2d2, 2d3, 2e2, 2e3, 2f1, 2f4, 2f5,
3.2, 3a, 3a1, 3a2, 3b1, 3b2, 3b4, 3c1, 3e2, 3g1
4.1, 4,3, 4a1, 4a2, 4a3, 4b1, 4b2, 4b3, 4b5, 4c2, 4e2, 4f1
5.1, 5.4, 5a1, 5a2
6a1, 6b1, 6c1, 6d1, 6d2
GR5

Table 7-5-1: Degraded Splice		
Situation	**Recommendations**	
1. Any high current circuit with one of more of the conditions identified below.	This finding is relatively infrequent. Pre-emptive replacement of spliced wire with new wire or the rework of splices can minimize the potential for repairs or splices to degrade beyond acceptable limits. Any repair should be accomplished using OEM/FAA approved methods and materials appropriate for the environment (which may exceed the requirements of originally approved practice for aged aircraft). Periodic diagnostic testing (e.g. resistance evaluation, time domain reflectometry) can help to identify failing (high resistance) repairs and splices.	OWNER
	1.1 Task Group 4: Update splicing practices as necessary. Consider procedure to tag locations of splices to aid in future visual inspections. Incorporation Plan: HWG7 – Splicing practices will be included in the minimum SWPM/ESPM content recommendations. Updated splicing practices, and procedures to identify splice locations, will be added to the SWPM/ESPM following development by the OEMs. Supplemental OEM Comments: Based on the information provided in the IIWG report coupled with the results of the non-intrusive inspection, review of the recommended splicing practices indicated that no changes to the present splicing practices have been identified. The OEMs firmly believe that the proper use of their standard wiring processes and procedures will result in a permanent installation that will not degrade over time.	Task 7

	Recommendations regarding the use of splices, including the maximum number of splices to be used within a single wire run are provided in the standard wiring practices manuals. The Boeing ESWPM recommends replacement of the wire as preferred to splice repair, and cites a maximum of three repair splices per wire run. The Airbus ESPM recommends replacement of the wire as preferred to splice repair, and cites a maximum of three repair splices per wire run. For EFCS and sensitive cables, splice repair is not approved as permanent repair, when feeder splice repair is not allowed above certain gauges.	
	Tagging or physical identification of the splice location is not presently a recommended practice. Due to the nature of the splice installation practices, a repair splice is usually placed on the outside of the wire bundle where it is visible for conditional inspection. The system in which the wire applies may be determined by verifying the wire number, and the system to which the wire applies can be verified by consulting the Wiring Diagram Manual. Some OEMs specify the system directly on the wiring. As splices are added to the wiring during repair, and the entire length of the wiring run may not be readily accessible to determine the total number of splices within that run, the OEMs recommend that documenting the splice location within the WDM is preferable to physically tagging the splice on the airplane. In addition, because the WDM would include information on the location of production, production repair, and in-service repair the splices, and the splices would be visible on the airplane, tagging a splice for future inspection would not be necessary. The OEMs will include within their ESWPM documents recommendations that operators record the location of repair splices for future reference. HWG6 has drafted advisory material on the use of non-environmental/environmental splices in the new AC/ACJ 25HAC/ACJ1703, Function and Installation for EWIS, paragraph (A)(2)(ix). See HWG6 Final Report, Appendix D, Section 1	
	1.2 Task Group 5: Update training guidelines on a regular basis to correspond to ESPM updates. Emphasize the need to inspect splices closely for obvious deterioration as well as proper materials and workmanship. Incorporation Plan:	Task 8

	HWG8 - Wiring splice inspection and selection is covered in the Inspection Module C4: Wiring System Damage. And the Wire Module E6 (e): Terminals and splices.	
	1.3 Aircraft Manufacturers: Where appropriate utilize design practices which facilitate the repair of electrical interconnect systems without the need for splices. Develop splice vs. replacement of wire guidelines. Incorporation Plan: Recommendations regarding the use of splices, including the maximum number of splices to be used within a single wire run are provided in the standard wiring practices manuals. The Boeing SWPM manual recommends replacement of the wire as preferred to splice repair, and cites a maximum of three repair splices per wire run. The Airbus ESPM manual recommends replacement of the wire as preferred to splice repair, and cites a maximum of three repair splices per wire run. For EFCS and sensitive cables, splice repair is not approved as permanent repair, when feeder splice repair is not allowed above certain gauges.	OEMs
	The prohibition of splices within these systems is due to the nature of the system operation rather than the physical location of the wire harness. Guidelines regarding the placing of splices within a wire bundle and the use of splices within a SWAMP area are already specified. Although Boeing recommends the replacement of a wire over use of a repair splice, a properly installed repair splice is an effective and permanent repair of wiring. Airbus design practices are to use interconnect elements and production splices are minimized to specific zones where installation of connective devices is impracticable. Although Airbus recommends replacement of the wire as preferred to splice repair, a properly installed repair splice is an effective and permanent repair of wiring The use of splices is a necessary and effective method of branching systems during airplane manufacture. Although wire replacement rather than repair is preferred, the nature of wire routing throughout the airframe, the reduced reliability associated with wiring designs with an increased number of connectors, and the limited access to all individual wires, necessitates the use of splices for repair. The specification of which type of manufacturing splice is used in each situation is reflected within the OEM standard wiring practices documents, i.e. what is accomplished during production is permitted on in-service airplanes.	

	In addition, the OEMs have already or will soon begin to require the use of only environmental splices of wiring in all locations of the airplane during production. As far as post-delivery modifications are concerned, Airbus is currently reviewing the ESPM content related to wire routing and segregation and will include in the ESPM guidance and recommendations in case of new wiring installation after delivery to the aircraft	
	1.4 Aircraft Operators: Review initial and proficiency training practices for splice installation and inspection. Ensure full awareness of approved materials and techniques. Incorporation Plan: HWG8 - Initial and proficiency training practice of splicing must be carried out using hands-on practice in conjunction with operator's PMI review.	Task 8
	1.5 Other: (a) The FAA should revise AC 43-13-1B to stipulates that environmental splices are the preferred method of repairing wire in both SWAMP and non-SWAMP areas. (b) Develop wiring configuration management software that will track the installation and location of splices. (c) Develop best practices regarding the maximum number of splices permitted for various types of circuits based upon frequency and severity of potential splice failures.	(a) Task 6 (b/c)OEMs
	Incorporation Plan: (a) HWG6 has drafted advisory material on the use of non-environmental/environmental splices in the new AC/ACJ for EWIS. See HWG6 Final Report, Appendix D, Section 1. OEMs (b) Development by the OEMs of software to record the location of repair splices on in-service airplanes was determined to be an inappropriate recommendation. Should a tracking procedure be deemed beneficial the method of identifying, recording, or tracking repair splices on in-service airplanes should be assessed by the individual operator based upon their knowledge and expertise. The OEMs account for production splices and indicate the location of these splices within the Wiring Diagram Manual. Manufacturing repair splices are accounted for in the disposition of production rejection or repair tags, which are	

	provided to the operator prior to airplane delivery. Repair splices made by the operator or mod center could be annotated on the wiring diagram in the same manner. The answers to questions regarding location, type, load, or limitations on the frequency of use are unique to the OEM. This information can be obtained by referring to the individual standard wiring practices manual for that OEM. Please note that the guidelines provided to operators regarding the number, location, type or frequency of splices do not comprise limitations, nor does exceeding these guidelines pose a safety concern. Due to the need for additional slack within a wire bundle when installing a splice, rarely are multiple splices installed on the same wire between connectors. The vast numbers of multiple repairs are addressed by replacing the damaged wire or adding a supplemental wire to the bundle rather than using multiple splices. Due to this practice documenting the location of repair splices within a software program would be more onerous than beneficial. OEMs (c) OEM's presently specify in the ESWPM the maximum number of splices permissible for all circuits (Splicing and wiring replacement guidelines are presently available in SWPM 20-10-13, Paragraph 4 for Boeing models and SWPM 20-10-03, Paragraph 1 for Douglas models). Lockheed design requirements specify the maximum number of splices permissible for all circuits. LMCO will update and incorporate this data into the revision of the SWPM.	
Situation	**Recommendations**	
1a. Potential for high resistance heating, flammable materials	Given the specified conditions, the occurrence of this fault could lead to potentially critical consequences. In this situation the potential for fire exists.	OWNER
	1a1 Aircraft Manufacturers: Consider updating splicing practice to reflect special considerations associated with 1) the proximity of the splice to non-fire-retardant materials and 2) the expected wire current. Incorporation Plan: OEM's	OEMs Task 6

	Splices are specified in the wiring design based upon the wire size, a direct result of the load on the circuit. As the fire-retardancy properties of adjacent materials is not normally known during the design or repair of the electrical system, this recommendation is impractical. Typically the most restrictive condition, such as the presence of fuel vapor, is used to assess the splice type and installation technique, rather than assess the type and proximity of all adjacent materials within a wiring run. To address special conditions the use of only environmental splices is one option, the replacement of non-fire retardant or flammable materials another, and the proper use and installation of appropriate splices to reduce the potential of high-resistance heating of the splice a third. The OEMs will consider any forthcoming recommendations regarding improvements in splicing practices to prevent the potential for high resistance heating in the presence of flammable materials. In addition, the OEMs have already or will soon begin to require the use of only environmental splices for repairs in all locations of the airplane during production. HWG6 - HWG6 has drafted advisory material on the use of splices in those areas containing non fire retardant material in the new AC/ACJ for EWIS. See HWG6 Final Report, Appendix D, Section 1.	
Situation	**Recommendations**	
1b. Potential for high resistance heating, multiple critical systems	Given the specified conditions, the occurrence of this fault could lead to potentially critical consequences. In this situation the potential exists for loss of several flight-critical systems.	OWNER
	1b1 Aircraft Manufacturers: Consider updating splicing practice to reflect special consideration associated with high-current carrying splices in bundles with wire supporting multiple flight-critical systems. OEMs Splices are specified in production based upon the wire size, a direct result of the load on the circuit. The OEM ESWPM typically provides special procedures for routing and splicing of power feeder cables. However, noting the expected actions of HWG6, the OEMs will consider any forthcoming recommendations regarding improvements in splicing practices related to high-current applications adjacent to or	OEMs

	within wire bundles containing flight-critical systems. Manufacturers have already or will soon begin to require the use of only environmental splices for repairs of wiring in all locations of airplane. As already mentioned in the owner remarks to recommendation 1.3, Airbus does not allow feeder repair above certain gauges, depending of the nature of the conductor (copper or aluminum). This is fully explained in the ESPM Chapter 20-53-25. Boeing provides power feeder repair information within SWPM 20-10-13 and power feeder splice procedures within SWPM 20-30-12.	
Table 7-5-2: Heat Damaged or Burnt Wire		
Situation	**Recommendations**	
2. Any situation with one or more of the specific conditions identified below	This finding is relatively common. Localized heat damage (from external source or internal conductor heating) on adjacent wires may make these wires particularly subject to the formation of neighboring cracks and the potential for arcing or shorting. Visual Inspection can detect some conditions. Use of in-situ nondestructive testing methods may be used to detect additional insulation faults, especially if the heat damage effects a local area with several bundles, several wires within a single bundle, or a substantial length of a single wire.	OWNER
	2.1 Task Group 3: Modify the MSG3 process to include the consideration of potential heat sources when developing zonal inspection instructions Incorporation Plan: HWG9 - MSG3 Rev 2001.1 EZAP logic requires assessment of environment in the selection of wiring system tasks and intervals. Presence of a heat source or other condition deemed hostile to wiring will be considered in the selection of tasks and intervals for wiring in the zone.	Task 9
	2.2 Task Group 4: Insure heat shield installation and maintenance are appropriately specified. Incorporation Plan: HWG7 - Heat shields are typically included with the potentially offending system i.e. the installation and maintenance of which are not normally included in the ESWPM. The minimum content of the ESWPM will include reference made to offending systems and the importance of	Task 7

	maintaining wiring protection systems.	
	2.3 Task Group 5: Review visual indications of overheating in order to more precisely characterize symptoms of heat-degraded wire. Incorporation Plan: HWG9 - Recommendations from the Task 3 Report include guidance for accomplishing Zonal Inspections, with a list of discrepant conditions that should be visually identifiable, including, "Discoloration/evidence of overheat on terminal lugs/blocks", and wire damage "...due to mechanical impact, overheat, localized chafing, etc.". This guidance is included in the recommended content of an FAA Advisory Circular as per ATSRAC Task 9.3.	Task 9
	2.4 Aircraft Manufacturers: Review design and maintenance practices regarding the use heat shields. Establish on-condition criteria for the replacement of wire in heat-damaged bundles (external and internal heat). Develop and implement configuration management processes to prevent load creep that may result in circuits operating near the rated capacity and conductor heating. Incorporation Plan Summary OEM's - Expected and actual sources of heat impinging on electrical wiring are presently taken into consideration during the design of the electrical system. OEM heat and moisture protection guidelines used in the design of the wiring systems indicates that this information is of a general nature, accounting for the wiring environment, the type of wiring specified for use in the area, and installation details. Inclusion of this information within the ESWPM is not practical. Allowable wire damage criteria is presently specified in the appropriate ESPWM, for example allowable wire damage and replacement criteria are provided in chapter 20-10-13, Paragraphs 1 and 2 for Boeing models and 20-00-06, Paragraph 4 for Douglas models. Additional protection is provided in locations where in service experience dictates that protection is needed. For example, Lockheed Martin requires the use of Bentley Harris type sleeving and segregation from heat producing equipment to address known heat sources. Operators are expected to identify areas of heat-damaged wiring during normal maintenance activities and take appropriate action. One appropriate action is to request that the OEM develop and provide fleet wide protection if the damage is expected to occur on other airplanes, or if the nature of the damage is	OEMs

considered to impugn safety.

A review of OEM design standards, Advisory Circulars, and industry design guidelines in an effort to establish whether guidance on the placement of heat and moisture protection is presently available or can be created indicates that, while much of the information available states that wiring should be protected from heat and moisture sources, the guidance does not extend to a description as to how or when that protection should be required.

In the case where there is a constant heat source, such as within the engine nacelle or strut area, high-temperature wiring is normally specified. In cases where failure of a high-temperature component, such as a pneumatic duct, could result in hot air impinging on the wiring a heat shield is specified. Where fluids could contact wiring, or in high-humidity environments such as the area above the cabin ceilings, either a moisture barrier or drip loops within the wiring run are specified to prevent the fluids from contacting exposed conductors. There are no definitive requirements that can be provided to operators so that they may determine whether heat or moisture protection is missing. The necessity for such protection is determined through an evaluation of the electrical system design, the environment in which it is installed, and the nature of the adjacent systems.

In summary, as the OEM heat and moisture protection guidelines used in the design of the wiring systems indicates that this information is of a general nature, accounting for the wiring environment, the type of wiring specified for use in the area, and installation details; inclusion of design guidelines for the installation of heat and moisture barriers within the ESWPM is not practical.

Electrical load documents are provided by all OEM's with the delivery of new airplanes. Boeing conducts electrical load analysis (ELA) on in-service airplanes upon request. Airbus supplies the ELA in an electronic format to allow the operator to update the actual electrical load of the aircraft following post delivery modification of the aircraft. Managing changes to the airplane electrical system, including ensuring that appropriate system capacity is not exceeded, is the responsibility of the owner/operator.

As far as post-delivery modifications are concerned, Airbus is currently reviewing the ESPM content related to wire routing and segregation and will include in the ESPM guidance and recommendations in case of new wiring installation after delivery to the aircraft.

HWG 6 Comments:

A new rule has been drafted, 25.1709, to protect EWIS from heat damage. Corresponding Advisory Materials is included in the new AC/ACJ 25H1709 for EWIS. See HWG6 Final Report, Appendices A, B, and D, Item 3.

2.5 Aircraft Operators: Ensure awareness of the heat-shield requirements and proper maintenance. Task 8/9

Incorporation Plan:

HWG9 - Installation of heat shields are an OEM design issue, and existing Zonal Inspection requirements should be adequate to detect malfunction, degradation, or failure of a heat shield. However, it is possible that a heat shield could inadvertently be left off after performing maintenance in a zone and the missing shield would not necessarily be clearly evident. While this could happen on any aircraft, T9HWG concludes that older aircraft that have undergone repetitive heavy maintenance events are more likely to have experienced such a situation. T9HWG recommends that aircraft manufacturers provide guidance to Operators where all such heat shields are required on each aircraft model. If an Operator finds that inadvertent removal has occurred, consideration should be given to enhancement of maintenance documents (task cards, manuals, etc.) with additional information to ensure compliance with heat shield installation requirements.

Supplemental OEM Comments:

As with any component installed on the airplane, except as cited within the Configuration Deviation List contained within the Dispatch Deviations Procedures Guide, protective shields and guards are required to be installed on the airplane during revenue service. The OEMs provide wiring protection in specific cases and expect that that protection will remain on the airplane indefinitely. The reinstallation of removed equipment is a standard practices and a regulatory requirement. It is the responsibility of each operator to ensure that the design integrity of the airframe is properly maintained and to incorporate maintenance and inspection programs that follow industry best maintenance practices. The OEM's believe that, although there exists the possibility that some protection may have been inadvertently omitted

on airlines undergoing extensive modification, we believe that the existing maintenance procedures in place at the airlines would dictate that such omissions would be rare. We also believe that the effects of such an omission would be minor in scope but still recognizable through normal or enhanced maintenance activities.

Operators should use the guidance provided in the forthcoming enhanced wiring inspection programs, coupled with the guidance contained within the OEM standard wiring practices documents to either identify damage caused from missing drip or heat shields, or identify the conditions that would necessitate protection. The OEMs believe that any wiring systems training program should emphasize the purpose and necessity of wiring protection systems.

Finally, concerning the installation of post-delivery modifications, OEM design practices, and the resulting guidance used to maintain those designs, are proprietary to the OEM. The requirement to use these practices and procedures for designs created by entities other than the OEM is inappropriate. Although the ESWPM is not considered to be a wiring standards document for designs of new installations, operators and STC applicants may refer to these guidelines in development of their installations.

As far as post-delivery modifications are concerned, Airbus is currently reviewing the ESPM content related to wire routing and segregation and will include in the ESPM guidance and recommendations in case of new wiring installation after delivery to the aircraft. Boeing will conduct a similar review based upon the forthcoming HWG6 recommendations.

HWG9 Follow on comments:

HWG9 concurs that there is insufficient evidence of problems related to missing drip or heat shields to warrant a fleet wide campaign to check for shield installation. Determination of type and number of shields per individual aircraft configuration and post delivery modification would be complex and considered unjustified

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2.6 Other: Develop diagnostic technologies and techniques to identify and prevent the development of high resistance interconnects. — OEMs

Incorporation Plan:

	The OEMs believe that proper installation of connections, terminal blocks, splices, etc. will prevent development of high resistance interconnects. The development of diagnostic technologies and techniques to either identify the potential for or development of high-resistance interconnects is not necessary given that visual indicators, such as discoloration, apparent during detailed visual inspections will identify high resistance interconnects. System monitoring will identify system effects as a result of high resistance interconnects. In addition, implementation of the EZAP program recommended by HWG9, and the inherent detailed (DET) and general (GVI) visual inspections that will result, should increase the frequency of which high-resistance interconnects are identified. However, the OEMs are actively either developing or evaluating wiring test equipment intended to determine the condition of wiring. The need to assess the development of high-resistance interconnects will be accounted for in this evaluation.	
Situation	**Recommendations**	
2a. Flammable materials, cockpit or electronics bay.	Given the specified conditions, the occurrence of this fault could lead to potentially critical consequences. Though the specific presence of moisture or contamination (to enable short circuiting) is not necessarily anticipated in this scenario, the specified zones and installations within these zones are critical enough to warrant extra care and precaution.	OWNER
	2a1 Task Group 3: Investigate periodic, selective inspection and nondestructive testing of cockpit and electronics bay wiring. Incorporation Plan: HWG9 - EZAP requires full application of the logic in the cockpit and electronics bay regardless of whether combustible materials are likely to be present. Due to the congestion and difficult access to these zones, it is expected that a Zonal Inspection will not be assessed as adequate. The logic will identify dedicated visual inspections, which could be Detailed Inspections in specific areas that warrant closer attention. While "periodic" and "selective" visual inspections will be identified, the use of non-destructive testing is insufficiently mature to apply on a scheduled basis at this time. Initially, new NDT methods would likely be used to support trouble-shooting activities, which will provide the necessary experience to allow assessment of their use in scheduled maintenance. To further mitigate the concern for wiring in cockpit and electronics bay areas, EZAP requires	Task 9

	consideration of the presence of combustible materials in a zone, and identification of tasks to remove significant accumulations of combustible contamination. In addition, enhancements to maintenance practices are proposed that will minimize the risk of damage and contamination to wiring caused by maintenance activity.	
	2a2 Aircraft Manufacturers: Investigate periodic, selective inspection and nondestructive testing of cockpit and electronics bay wiring. Incorporation Plan: Airbus and Boeing presently conduct periodic inspections of airplanes, including the E/E bay and flight deck. Selective inspections, as a result of in-service experience, are evaluated on a case-by-case basis. The information collected as a result of these inspections is used to improve and update, as required, the current electrical design, technology of electrical components and technical design directives. Lockheed - LMCO addresses wiring concerns utilizing Service Information Letter (SIL) 24-10. This SIL is updated periodically to include new information and concerns received. Recurring wiring related problems are addressed via Service Bulletins. Inspections and lab testing of in service wiring is not presently done due to the reduction of resources allocated for the L-1011. On aircraft wiring issues are addressed via SILs, Customer Technical Support and the Engineering Support staff. The OEMs believe current ongoing assessments, in addition to the enhanced zonal inspections emanating from the EZAP, should result in an increased frequency and intensity of inspection.	OEMs
	2a3 Aircraft Operators: Investigate periodic, selective inspection and nondestructive testing of cockpit and EE bay wiring. Accelerate removal of flammable materials from the cockpit and electronics bay. Incorporation Plan Summary	Task 9

	HWG9 - EZAP requires full application of the logic in the cockpit and electronics bay regardless of whether combustible materials are likely to be present. Due to the congestion and difficult access to these zones, it is expected that a Zonal Inspection will not be assessed as adequate. The logic will identify dedicated visual inspections, which could be Detailed Inspections in specific areas that warrant closer attention. While "periodic" and "selective" visual inspections will be identified, the use of non-destructive testing is insufficiently mature to apply on a scheduled basis at this time. Initially, new NDT methods would likely be used to support trouble-shooting activities, which will provide the necessary experience to allow assessment of their use in scheduled maintenance. To further mitigate the concern for wiring in cockpit and electronics bay areas, EZAP requires consideration of the presence of combustible materials in a zone, and identification of tasks to remove significant accumulations of combustible contamination. In addition, enhancements to maintenance practices are proposed that will minimize the risk of damage and contamination to wiring caused by maintenance activity.	
Situation	**Recommendations**	
2b. Moisture, flammable materials, multiple critical systems	Given the specified conditions, the occurrence of this fault could lead to potentially severe consequences. Effective intervention can include reduction of moisture intrusion and minimization of flammable materials in the proximity of susceptible installations. Installation of heat shielding to protect susceptible installations can eliminate or mitigate heat damage. Because embrittled wires can fail collectively, proper separation of critical system wiring is essential.	OWNER
	2b1 Task Group 3: Investigate periodic, selective inspection and non-destructive testing of wire bundles supporting multiple flight critical systems. Incorporation Plan: HWG7 - This action should rightly be addressed by HWG9 as it concerns the periodic inspection of specific wiring. Supplemental Comments: HWG9 - EZAP logic will identify dedicated visual inspections or a detailed inspection in specific areas that warrant closer attention. While "periodic" and "selective" visual inspections will be identified, the use of non-destructive testing is insufficiently mature to apply on a scheduled basis at this time. Initially, new NDT methods would likely be used to support troubleshooting activities, which will provide the necessary experience to allow assessment of their use in	Task 7

scheduled maintenance.

2b2 Task Group 4: Insure that drip guard installation and maintenance are appropriately specified — Task 9

Incorporation Plan:

HWG9 - Installation of drip shields are an OEM design issue, and existing Zonal Inspection requirements should be adequate to detect malfunction, degradation, or failure of a drip shield. However, it is possible that a drip shield could inadvertently be left off after performing maintenance in a zone and the missing shield would not necessarily be clearly evident. While this situation could exist on any aircraft, T9HWG concludes that older aircraft that have undergone repetitive heavy maintenance events are more likely to have experienced such an event. HWG9 recommends that aircraft manufacturers provide guidance to Operators for all such drip shields required on each aircraft model. If inspection for the shields reveals inadvertent removal has occurred, consideration should be given to enhancement of maintenance documents (task cards, manuals, etc.) with additional information to ensure compliance with drip shield installation requirements.

Supplemental OEM Comments:

As with any component installed on the airplane, except as cited within the Configuration Deviation List contained within the Dispatch Deviations Procedures Guide, protective shields and guards are required to be installed on the airplane during revenue service. The OEMs provide wiring protection in specific cases and expect that that protection will remain on the airplane as long as the airplane is operated in revenue service. The reinstallation of removed equipment is a standard practices and a regulatory requirement. It is the responsibility of each operator to ensure that the design integrity of the airframe is properly maintained and to incorporate maintenance and inspection programs that follow industry best maintenance practices. The OEM's believe that, although there exists the possibility that some protection may have been inadvertently omitted on airlines undergoing extensive modification, we believe that the existing maintenance procedures in place at the airlines would dictate that such omissions would be rare. We also believe that the effects of such an omission would be minor in scope but still recognizable through normal or enhanced maintenance activities.

Operators should use the guidance provided in the forthcoming enhanced wiring inspection programs, coupled with the guidance contained within the OEM standard wiring practices documents to either identify damage caused from missing drip or heat shields, or identify the conditions that would necessitate protection. The OEMs believe that any wiring systems training program should emphasize the purpose and necessity of wiring protection systems.

Finally, concerning the installation of post-delivery modifications, OEM design practices, and the resulting guidance used to maintain those designs, are proprietary to the OEM. The requirement to use these practices and procedures for designs created by entities other than the OEM is inappropriate. Although the ESWPM is not considered to be a wiring standards document for designs of new installations, operators and STC applicants may refer to these guidelines in development of their installations.

HWG9 Follow on comments:

HWG9 concurs that there is insufficient evidence of problems related to missing drip or heat shields to warrant a fleet wide campaign to check for shield installation. Determination of type and number of shields per individual aircraft configuration and post delivery modification would be complex and considered unjustified

2b3 Aircraft Manufacturers: Review design practices regarding the use of drip shields for this specific situation; investigate periodic selective inspection and non-destructive testing of wiring. Develop updated wiring separation guidelines that consider loss of multiple critical functions from a common mode failure.

OEMs

Incorporation Plan:

Potential source of contamination of airplane wiring are identified by the OEMs during the design and development of the electrical system and appropriate protection in the form of drip or heat shields are included to minimize the effects of contamination. OEMs presently conduct periodic inspections of airplanes, including the E/E bay and flight deck. Selective inspections, as a result of in-service experience, are evaluated on a case-by-case basis. The information collected as a result of these inspections is used to improve and update, as required, the current electrical design, technology of electrical components and technical design directives and ESWPM guidelines.

	Wire separation guidelines outlined within the OEM standard wiring practices manuals reflect those used during and certified for airplane manufacture. These guidelines reflect only a portion of the methods used to meet the requirements outlined in FAR 25-1309 which states, in part, that the equipment, systems and installations must be designed so that the occurrence of any failure condition which would prevent the continued safe flight and landing is improbable, and that the analysis must take into account the probability of multiple and undetected failures. Although the OEM ESWPM provides guidelines on proper wire separation and segregation, it does not provide the reasons for these guidelines, nor does it provide the design standards for post-manufacture modifications. STC applicants can and should refer to the OEM guidelines when developing their modifications, but they are cautioned that the ESWPM is not intended as a design standard but, rather, for use in maintenance and repair of the OEM wiring installations. In addition to the above, any new requirements which may arise from HWG 6 Sub-tasks 6.7 (Wire Separation Requirements), 6.6 (Wire System Safety Assessment Requirements) and 6.8 (Wiring Identification Requirements) will be analyzed and documentation will be updated if appropriate.	
	2b4 Aircraft Operators: For this specific situation, (a) investigate periodic, selective inspection and non-destructive testing of wiring. (b) Investigate segregation and separation of wire installed after manufacture of the aircraft. Incorporation Plan: (a) Airbus/Boeing currently conducts periodic inspection of the aircraft wiring including the avionics bay and flight deck. The information collected as a result of these inspections is used to improve and update, as required, the current electrical design, technology of electrical components and technical design directives and ESWPM guidelines. (a) Lockheed - LMCO addresses wiring concerns via Service Information Letter (SIL) 24-10. This SIL is updated periodically to include new information and concurs raised by operators. Recurring wiring related problems are addressed via Service Bulletins. Wiring segregation is addressed in the ESWPM. It is the operator's responsibility to ensure the original design features are maintained.	(a) OEMs (b) FAA

	FAA (b) - The FAA will take action based on a review of recommendations from the HWG6 sub-group addressing wire separation issues (Task 6.7) following the submittal of ATSRAC's final report to the FAA October 2002. Note that WG 6 sub-group recommendations will be for FAR/JAR 25 and are not "investigative" (2b4 states "Investigate separation and segregation of wire installed after manufacture of the aircraft."	
Situation	Recommendations	
2c. Moisture, flammable materials	Given the specified conditions, the occurrence of this fault could lead to potentially severe consequences. Effective intervention can include reduction of moisture intrusion, minimization of flammable materials in the proximity of susceptible installations, and installation of fire or heat barriers.	OWNER
	2c1 Task Group 4: Insure that drip guard installation and maintenance are appropriately specified. Incorporation Plan: HWG7 - Moisture protection will be recommended as SWPM/ESPM minimum content. HWG8 - Drip guard installation and maintenance specifications are covered in the Housekeeping Module D2 (e): Galleys and toilets. Instructors must ensure that the student knows the airplane documentation that illustrates the correct installation. HWG9 - Installation of drip shields is an OEM design issue, and existing Zonal Inspection requirements should be adequate to detect malfunction, degradation, or failure of a drip shield. However, it is possible that a drip shield could inadvertently be left off after performing maintenance in a zone and the missing shield would not necessarily be clearly evident. While this situation could exist on any aircraft, T9HWG concludes that older aircraft that have undergone repetitive heavy maintenance events are more likely to have experienced such an event. T9HWG recommends that aircraft manufacturers provide guidance to Operators for all such drip shields required on each aircraft model. If inspection for the shields reveals inadvertent removal has occurred, consideration should be given to enhancement of maintenance documents (task cards, manuals, etc.) with additional information to ensure compliance with drip shield installation requirements (see OEM response below and OEM follow-up). OEM response	Task 7/8/9

As with any component installed on the airplane, except as cited within the Configuration Deviation List contained within the Dispatch Deviations Procedures Guide, wiring protection shielding and guards are required to be installed on the airplane during revenue service. Replacement of removed shields and guards is both a standard practice and a regulatory requirement. It is the responsibility of each operator to ensure that the design integrity of the airframe is properly maintained and to incorporate maintenance and inspection programs that follow industry best maintenance practices.

The OEM's believe that, although there exists the possibility that some protection may have been inadvertently omitted on airlines undergoing extensive modification, we believe that the existing maintenance procedures in place at the airlines would dictate that such omissions would be rare. We also believe that the effects of such an omission would be minor in scope but still recognizable through normal or enhanced maintenance activities.

Operators should use the guidance provided in the forthcoming wiring inspection programs, coupled with the guidance contained within the OEM standard wiring practices documents to either identify damage caused from missing drip or heat shields, or identify the conditions that would necessitate protection. The OEMs believe that any wiring systems training program should emphasize the purpose and necessity of wiring protection systems.

HWG9 Follow up remarks:

HWG9 concurs that there is insufficient evidence of problems related to missing drip or heat shields to warrant a fleet wide campaign to check for drip shield installation. Determination of type and number of drip shields per individual aircraft configuration and post delivery modification would be complex and considered unjustified.

2c2 Aircraft Manufacturers: Review design practices regarding the use of drip guards for this specific situation. Investigate the use of nondestructive testing to troubleshoot suspect wire installations. — OEMs

Incorporation Plan:

Moisture ingression prevention is presently taken into consideration during the design of the electrical system. Boeing moisture ingression prevention guidelines are specified in the ESWPM and are commonly used during the production of new airplanes. Airbus will include in the ESPM

	guidance and practices to maintain the design provisions for the prevention of moisture contamination to wiring. The Lockheed ESWPM manual provides practices specific to SWAMP locations. The use of general and detailed visual inspections of wiring installed in airplanes remains the preferred method of detecting actual or the potential for damage to wiring. This preference accounts for the present level of diagnostic equipment available to the industry, the needs of the industry, and the potential for undetected damage to result in failure. As stated previously, the OEMs continue to consider NDT methods other than visual inspections as a method of identifying actual or potential wiring faults.	
Situation	**Recommendations**	
2d. Moisture, multiple critical systems	Given the specified conditions, the occurrence of this fault could lead to potentially severe consequences. Though the presence of flammable materials is not anticipated in this scenario, the potential for a common mode failure of many or all wires in a single bundle warrants extra care and precaution. Effective intervention can include reduction of moisture intrusion and installation of fire or heat barriers. Proper separation of critical systems wiring will mitigate the consequence of collective wire failure.	OWNER
	2d1 Task Group 3: 2d2 Task Group 4: Insure that drip guard installation and maintenance are appropriately specified. Incorporation Plan: HWG7 - Moisture protection will be required as ESWPM minimum content. HWG8 - Drip guard installation and maintenance specification is covered in the Housekeeping Module D2 (e): Galleys and toilets. Instructors must ensure that the student knows the airplane documentation that illustrates the correct installation. HWG9 - Installation of drip shields is an OEM design issue, and existing Zonal Inspection requirements should be adequate to detect malfunction, degradation, or failure of a drip shield. However, it is possible that a drip shield could inadvertently be left off after performing maintenance in a zone and the missing shield would not necessarily be clearly evident. While this situation could exist on any aircraft, HWG9 concludes that older aircraft that have undergone repetitive heavy maintenance events are more likely to have experienced such an event. HWG9 recommends that aircraft	Task 7/8/9

manufacturers provide guidance to Operators for all such drip shields required on each aircraft model. If inspection for the shields reveals inadvertent removal has occurred, consideration should be given to enhancement of maintenance documents (task cards, manuals, etc.) with additional information to ensure compliance with drip shield installation requirements.

Supplemental OEM Comments:

As with any component installed on the airplane, except as cited within the Configuration Deviation List contained within the Dispatch Deviations Procedures Guide, protective shields and guards are required to be installed on the airplane during revenue service. The OEMs provide wiring protection in specific cases and expect that that protection will remain on the airplane as long as the airplane operates in revenue service. The reinstallation of removed equipment is a standard practices and a regulatory requirement. It is the responsibility of each operator to ensure that the design integrity of the airframe is properly maintained and to incorporate maintenance and inspection programs that follow industry best maintenance practices. The OEM's believe that, although there exists the possibility that some protection may have been inadvertently omitted on airlines undergoing extensive modification, we believe that the existing maintenance procedures in place at the airlines would dictate that such omissions would be rare. We also believe that the effects of such an omission would be minor in scope but still recognizable through normal or enhanced maintenance activities.

Operators should use the guidance provided in the forthcoming enhanced wiring inspection programs, coupled with the guidance contained within the OEM standard wiring practices documents to either identify damage caused from missing drip or heat shields, or identify the conditions that would necessitate protection. The OEMs believe that any wiring systems training program should emphasize the purpose and necessity of wiring protection systems

HWG9 Follow on comments:

HWG9 concurs that there is insufficient evidence of problems related to missing drip or heat shields to warrant a fleet wide campaign to check for shield installation. Determination of type and number of shields per individual aircraft configuration and post delivery modification would be complex and considered unjustified

	2d3 Aircraft Manufacturers: Review design practices regarding the use of drip guards. Investigate use of nondestructive testing to trouble-shoot suspect wire installations. Incorporation Plan: Moisture ingression prevention is presently taken into consideration during the design of the electrical system. Boeing moisture ingression prevention guidelines are specified in the ESWPM and are commonly used during the production of new airplanes. Airbus will include in the ESPM guidance and practices to maintain the design provisions for the prevention of moisture contamination to wiring. The Lockheed ESWPM manual provides practices specific to SWAMP locations. The use of general and detailed visual inspections of wiring installed in airplanes remains the preferred method of detecting actual or the potential for damage to wiring. This preference accounts for the present level of diagnostic equipment available to the industry, the needs of the industry, and the potential for undetected damage to result in failure. The OEMs continue to consider NDT methods other than visual inspections as a method of identifying actual or potential wiring faults.	OEMs
	2d4 Aircraft Operators: Investigate separation and segregation of wire installed after manufacture of the aircraft. Incorporation Plan: FAA - The FAA will take action based on review of the recommendations from the HWG6 sub-group addressing wire separation issues (Task 6.7) following the submittal of ATSRAC's final report to the FAA October 2002. Note that HWG 6 sub-group recommendations will be for FAR/JAR 25 and are not "investigative" (2b4 also states "Investigate separation and segregation of wire installed after manufacture of the aircraft." HWG6 - HWG6 has drafted a new rule on this subject (25.1709), and corresponding advisory material in the new AC/ACJ for EWIS. See HWG6 Final Report, Appendices A, B and D, Item 18	FAA Task 6
Situation	**Recommendations**	
2e. Flammable materials or contamination, multiple critical systems	Given the specified conditions, the occurrence of this fault could lead to potentially severe consequences. The potential for a common mode failure of many or all wires in a single bundle warrants extra care and precaution.	OWNER

	2e1 Task Group 3: 2e2 Task Group 4: Ensure that wiring separation and segregation guidelines that consider loss of multiple critical functions from a common mode failure are specified. Incorporation Plan Summary: HWG6 - HWG6 has drafted new rules on this subject (25.1705, 25.1709), and corresponding advisory material in the new AC/ACJ for EWIS. See HWG6 Final Report, Appendices A, B and D HWG7 - Wiring physical separation requirements will be required as ESWPM minimum content. Wire separation guidelines outlined within the OEM standard wiring practices manuals reflect those used during and certified for airplane manufacture.	Task 6/7
	2e3 Aircraft Manufacturers: Investigate use of nondestructive testing to trouble-shoot suspect wire installations. Review sources of potential contamination. Incorporation Plan: Currently available NDT/troubleshooting methods are provided within the specific airplane maintenance manual chapters appropriate for the system-undergoing test. OEMs are presently evaluating the use of diagnostic equipment utilizing various technologies to identify actual or the potential for wiring faults. OEMs presently examine model-specific sources of contamination and release service literature indicating how those systems could be adjusted or modified to minimize the potential for contamination. This service literature was reviewed by industry teams responsible for accomplishing ATSRAC Tasks 1 and 2. In addition, the OEMs expect that the EZAP, which contains specific evaluation of the actual and potential sources of contamination within a zone, would address the need for changes in maintenance or a design change to preclude the possibility of subsequent contamination. The Airbus ESPM currently provides guidelines for the cleaning of EWIS components (Chapter 20-55-00) and protection (Chapter 20-54-00) during maintenance. Any HWG7 and HWG9 recommendations will be analyzed and included if appropriate. Both Boeing Standard Wiring Practices Manuals incorporate wire cleaning and inspection practices (20-10-04 and 20-00-06 applicable to the Puget	OEMs

	Sound and Long Beach airplanes, respectively). Recommended guidelines for protection of wiring during maintenance are in development and will be included in both SWPM in the next revision(s).	
	2e4 Aircraft Operators: - Investigate separation and segregation of wire installed after manufacture of the aircraft. Review sources of potential contamination. Incorporation Plan: FAA - The FAA has awarded a research contract to Raytheon Technical Services Company (RTSC) to assess requirements for separation and segregation. RTSC will conduct testing as part of this assessment.	FAA
Situation	**Recommendations**	
2f. Flammable materials, multiple critical systems, vibration	Given the specified conditions, the occurrence of this fault could lead to potentially severe consequences. Though moisture is not anticipated in this scenario, the potential for vibration (i.e. the relative motion of partially exposed conductors) to induce a common mode failure of many or all wires in a single critical bundle warrants extra care and precaution. Effective intervention can include reducing vibration potential with additional bundle security (clamps, ties, etc) and minimizing flammable materials in the proximity of susceptible installations.	OWNER
	2f1 Task Group 3: 2f2 Task Group 4: Ensure that wiring separation and segregation guidelines that consider loss of multiple critical functions from a common mode failure are specified. Incorporation Plan: HWG6 has drafted new rules on this subject (25.1705, 25.1709), and corresponding advisory material in the new AC/ACJ for EWIS. See HWG6 Final Report, Appendix D. HWG7 - Wiring physical separation requirements will be required as ESWPM minimum content. General guidelines concerning wiring segregation and separation are specified by the OEM.	Task 6/7
	2f3 Task Group 5: Insure that training adequately addresses wire bundle segregation clamp and tie best practices specifically with regard to high vibration areas. Incorporation Plan:	Task 8

	HWG8 - Wire bundle separation and clamping best practices are covered in Wire Module E4 (b, d & e); Separation rules, Clamp inspection and Clamp removal and fitting. Lacing best practices will be covered in Wiring Practices Documentation Module B3 (c): Electrical cable binding.	
	2f4 Aircraft Manufacturers: (a) Review design practices regarding the clamping and tying of wire bundles. (b) Investigate use of nondestructive testing to trouble-shoot suspect wire installations. Incorporation Plan: OEMs have conducted a review of wire clamping and bundle assembly techniques. This review is now complete with no changes deemed necessary. The expectation that release of an SFAR requiring that the ESWPM be included as part of the Instructions for Continued Airworthiness (FAR 25-1529, Appendix H) will ensure that operators will be using the guidelines outlined within that document, or using equivalent procedures developed using their own expertise. These ESWPM guidelines specify proper wire installation requirements, which account for minor errors or deviations. The use of general and detailed visual inspections of wiring installed in airplanes remains the preferred method of detecting actual or the potential for damage to wiring. This preference accounts for the present level of diagnostic equipment available to the industry, the needs of the industry, and the potential for undetected damage to result in failure. The OEMs continue to consider NDT methods other than visual inspections as a method of identifying actual or potential wiring faults.	OEMs
	2f5 Aircraft Operators: (a) Investigate use of nondestructive testing to trouble-shoot suspect wire installations. (b) Investigate separation and segregation of wire installed after manufacture of the aircraft. Incorporation Plan: (a) Boeing and Lockheed NDT/troubleshooting methods are provided within the specific airplane maintenance manual chapter appropriate for the system undergoing test. The Airbus ESPM currently provides electrical nondestructive testing to trouble-shoot electrical wiring. In addition to the techniques presently available, OEMs are currently evaluating the use of additional diagnostic equipment utilizing various technologies to identify actual or the	(a) OEMs (b) FAA

	potential for wiring faults. FAA - The FAA has awarded a research contract to Raytheon Technical Services Company (RTSC) to assess requirements for separation and segregation. RTSC will conduct testing as part of this assessment.	
Table 7-5-3: Vibration Damage or Chafing		
Situation	**Recommendations**	
3. Any Situation involving one or more of the conditions identified below	This finding is relatively common. If the chafing agent is a conductive to ground or if multiple adjacent wires are chafing, short-circuiting can occur even in the absence of moisture or a conductive contaminant (i.e. through direct physical contact). Augmenting general visual inspection with a detailed or directed visual inspection in critical areas can mitigate this condition. The necessity for rework or redesign may result from identification of chronic or widespread chafing condition. An AFCB can mitigate this condition by minimizing damage and preventing electrical fire.	OWNER
	3.1 Task Group 3: For these high consequence situations, specify more detailed inspection (possibly requiring some disassembly of support hardware) to ensure potential chafing problems are spotted and corrected. Incorporation Plan: HWG9 - MSG3 Rev 2001.1 EZAP logic requires assessment of environment in the selection of wiring system tasks and intervals. Conditions that could lead to clamp deterioration and/or chafing of wiring (extreme temperatures, high vibration, frequent maintenance access) or other conditions deemed hostile to wiring will influence the selection of tasks and intervals for wiring in the zone with selection of Detailed Inspection possible. Also, MSG3 Rev 2001.1 revised the definition of GVI to include use of a mirror to provide visual access to all exposed surfaces of an installation or item. This should provide enhanced surveillance of wire clamping provisions, and detection of deterioration by the GVI should be cause for further investigation, including clamp disassembly to check the underlying wiring. Recommendations from the Task 3 Report includes guidance for accomplishing Zonal Inspections, with a list of discrepant conditions expected to be identified by a Zonal Inspection, including "wiring clamp protection/cushion damaged." This guidance is included in the recommended content of an FAA Advisory Circular as per ATSRAC Task 9.3.	Task 9

	3.2 Task Group 4: Develop a catalog of unacceptable wire bundle configurations. Incorporation Plan: HWG8 - Recommends that the OEM's construct a graphical database of model and zone specific wire system faults for Instructor and Technician training and knowledge. OEM's The OEMs currently have no plans to create a readily accessible electronic library of unacceptable wire bundle configurations. As much of this data already exists with documentation readily available to the operator or repair station, the OEMs agree to provide upon request representative photographs or line drawings of unacceptable wire bundle configurations for training purposes. As far as Airbus Wiring System Training Course is concerned, representative photos of unacceptable wiring systems and/or connective devices installation/contamination will be part of the Airbus training documentation to illustrate typical problems found on the airplane.	OEMs Task 8
	3.3 Task Group 5: Develop enhanced training to ensure proper mechanical use of OEM/FAA approved tie downs, clamps, and wire separation/segregation are used in areas were wires or cables cross or come in contact. Ensure maintenance personnel recognize potential areas of chafing. Incorporation Plan: HWG8 - Proper mechanical use of OEM/FAA approved tie downs, clamps and wire separation is covered in Wire Module E4 (b, d & e); separation rules, Clamp inspection and Clamp removal and fitting. Tie best practices will be covered in Wiring Practices Documentation Module B3 (c): Electrical cable binding. Maintenance personnel will be trained to recognize potential areas of chafing using Inspection Module C4 (e) Vibration/chafing.	Task 8
	3.4 Aircraft Manufacturers: Continue development of arc-fault circuit breaker technology. Develop generic implementation plans for the potential retrofit of arc-fault circuit breakers onto in-service aircraft. Incorporation Plan: Boeing/Airbus - Implementation of any new technology will be evaluated as it is being developed and with the input of the operators. Lockheed - as AFCB technology is developed LMCO will continue to evaluate, with operators, the	OEMs

	applicability for individual systems. If found effective the OEMs will encourage the adoption of the technology.	
	3.5 Aircraft Operators: (a) Ensure that maintenance personnel are aware of the need to verify the security of all mounting hardware (i.e. specify tactile inspection). (b) Develop generic implementation plans for the potential retrofit of arc-fault circuit breakers onto in-service aircraft. Incorporation Plan: HWG8 - (a) Security of mounting hardware including tactile inspections are covered in Wire Module E3 (a & b): Inspection of individual wiring and Inspection of wire bundles. (b) Boeing/Airbus - Implementation of any new technology will be evaluated as it is being developed and with the input of the operators. Lockheed - as AFCB technology is developed LMCO will continue to evaluate, with operators, the applicability for individual systems. If found effective the OEMs will encourage the adoption of the technology.	(a) Task 8 (b) OEMs
Situation	**Recommendations**	
3a. Flammable materials or contamination, cockpit or electronics bay	Given the specified conditions, the occurrence of this fault could lead to potentially critical consequences. Wire or wire bundle chafing in the presence of flammable materials in the cockpit or electronics bay could result in wire-to-structure or wire-to-wire shorting arcing resulting in fire. Flammable contaminants increase the potential for ignition. More emphasis on cleaning and prevention of fluid contamination (e.g. drip shields) can mitigate the risks presented by contaminants and aid in the detection of chafing conditions. Nondestructive testing can detect wire chafing (after significant dielectric breakdown) and aid in repair.	OWNER
	3a1 Task Group 3: (a) Develop situation-specific guidance to ensure the proper attention to protection and cleaning wire bundles. (b) Develop guidance on the separation of wire bundles from non-fire-retardant materials. Incorporation Plan Summary: (a) HWG7 - General and conditional wiring protection and cleaning procedures will be included in the ESWPM as minimum content. General guidelines concerning possible wiring protection and cleaning procedures will be specified by the OEM.	(a) Task 7/8/9 (b) Task 6

	HWG8 - Protection and cleaning of wire bundles are covered in the Housekeeping Module D4, 5 & 6: Contamination Protection Planning, Protection During Airplane Maintenance, and Repair and Cleaning Processes HWG9 - EZAP requires full application of the logic in the cockpit and electronics bay irrespective of whether combustible materials are likely to be present. Due to the congestion and difficult access to these zones, it is certain that a Zonal Inspection will not be assessed as adequate. The logic will identify dedicated visual inspections, which could be Detailed Inspections in specific areas shown by the logic to warrant closer attention. While "periodic" and "selective" inspections will be identified, the use of non-destructive testing is insufficiently mature to apply on a scheduled basis. Initially, new NDT methods would likely be used to support troubleshooting activities, which will provide the necessary experience to allow assessment of their use in scheduled maintenance. To further mitigate the concern for wiring in cockpit and electronics bay areas, EZAP requires consideration of the presence of combustible materials in a zone, and identification of tasks to remove significant accumulations of combustible contamination. In addition, enhancements to maintenance practices ("Protection and Cautions") are proposed that will minimize the risk of damage and contamination to wiring caused by maintenance activity. Incorporation Plan Summary: (b) HWG6 has drafted a new rule on this subject (25.1709), and corresponding advisory material in the new AC/ACJ for EWIS. See HWG6 Final Report, Appendices A, B, and D.	
	3a2 Task Group 4: (a) Specify situation-specific standards to ensure wire bundles are properly protected and cleaned based on OEM approved practice. (b) Specify nondestructive testing procedures for validating wire integrity in response to undiagnosed malfunctions of cockpit electrical equipment. Incorporation Plan Summary: HWG7 - (a) General and conditional wiring protection and cleaning procedures will be included in the ESWPM as minimum content. OEM's: (b) Troubleshooting guidance for system anomalies are contained within the specific Airplane Maintenance Manual chapter applicable to that system. For Airbus, the ESWPM includes current technology electrical NDT testing methods. Additional troubleshooting procedures will be added to the Airplane Maintenance Manual or ESWPM as they become available.	(a) Task 7 (b) OEMs

3a3 Aircraft Manufacturers: Develop design modification to minimize potential for contamination. OEMs

Incorporation Plan:

OEMs - Potential sources of contamination of airplane wiring are identified by OEMs during the design and development of the airplane, and appropriate protection in the form of drip or heat shields are included to minimize the effects of contamination. When unanticipated sources of contamination are identified during service operation, additional protection is specified and available to operators through a service letter or service bulletin. In the case of general protection of wiring during unrelated maintenance, OEMs will provide protection guidelines in future revisions to their ESWPM.

Boeing is presently evaluating several methods of maintenance protection in various areas of an airplane. These recommendations must be validated with operators and repair stations before they are implemented into the ESWPM. At this time a definitive schedule is not available.

The Airbus ESPM currently provides guidelines for the cleaning of EWIS components (Chapter 20-55-00) and protection (Chapter 20-54-00) during maintenance. Any HWG7 and HWG9 recommendations will be analyzed and included if appropriate

In addition, based upon the ATSRAC and FAA recommendations that we do so, the OEMs are presently implementing notes into all service bulletins cautioning operators about the importance of protecting wiring during maintenance. Boeing incorporated this note starting in mid-2002. Airbus has launched corresponding actions to implement the EAPAS recommendation to include information in service data on minimizing wiring contamination during maintenance. A dedicated procedure is presently under preparation for introduction in the next available revision of the ESPM. This task will cover the recommendations and information included in ATA Specification 117. Airbus is investigating also the possibility to introduce this Task in the AMM. As soon as this specific Task will be available, a cross-reference to the ESPM or AMM will be made in all relevant Service Bulletins

	Lockheed has been adding notes to its SB's recommending the utilization ATA Specification 117 guidelines when performing maintenance in, on or around wiring. All L-1011 operators have been supplied a copy of the specification and are urged to implement it into their maintenance programs. The revision of the LMCO SWPM will provide reference to ATA specification 117. Additionally, review of our Maintenance Manuals shows that more notes should be added, regarding proper techniques and the use of suggested references. HWG6 has drafted new rules on fluid contamination (25.1703, 25.1709), and corresponding advisory material in the new AC/ACJ for EWIS. See HWG6 Final Report, Appendices A, B and D.	
Situation	**Recommendations**	
3b. Flammable materials or contamination, multiple critical systems	Given the specified conditions, the occurrence of this fault could lead to potentially critical consequences. Wire chafing in the presence of flammable materials or contaminants with wires from multiple critical systems in close proximity could result in smoke and/or fire and loss of multiple flight-critical systems. Maintaining wire segregation for critical and redundant systems can mitigate the risk of multiple system failures. More emphasis on cleaning and prevention of fluid contamination (e.g. drip shields) can mitigate the risks presented by contaminants and aid in the detection of chafing conditions.	OWNER
	3b1 Task Group 3: (a) Develop situation-specific guidance to ensure the proper attention to protection and cleaning wire bundles. (b) Develop guidance on the separation of wire bundles from non-fire-retardant materials. Incorporation Plan Summary: HWG7 - (a) General and conditional wiring protection and cleaning procedures will be included in the ESWPM as minimum content. General guidelines concerning possible wiring protection and cleaning procedures will be specified by the OEM. HWG8 - (a) Protection and cleaning of wire bundles are covered in the Housekeeping Module D4, 5 & 6: Contamination Protection Planning, Protection During Airplane Maintenance, and Repair and Cleaning Processes HWG9 - (a) MSG3, Rev 2001.1 EZAP logic includes a determination if accumulation of combustible material likely in a zone, and selection of task(s) to prevent significant accumulation of combustible material.	(a) Task 7/8/9 (b) Task6/OEMs

	HWG6 - (b) has drafted a new rule on this subject (25.1709), and corresponding advisory material in the new AC/ACJ for EWIS. See HWG6 Final Report, Appendices A, B and D. OEM's - (b) Spatial separation of wiring from structure, systems components, or other wiring is accounted for in the design of the wiring system.	
	3b2 Task Group 4: (a) Specify situation-specific standards to ensure wire bundles are properly protected and cleaned. (b) Specify updated wiring separation and segregation guidelines that consider loss of multiple critical functions from a common mode failure. (c) Specify nondestructive testing procedures for validating wire integrity in response to undiagnosed malfunctions of flight critical equipment. Incorporation Plan Summary: HWG7 - (a) General and conditional wiring protection and cleaning procedures will be included in the ESWPM as minimum content. OEM's - (b)(c) Wire separation and segregation guidelines are presently contained within the ESWPM and reflect current production design standard that account for loss of multiple or redundant systems. Any changes to the standards will be reflected in future revisions to the ESWPM. Troubleshooting procedures to determine the cause of any system malfunction or anomaly, including non-destructive troubleshooting of the system wiring, is contained within the specific Airplane Maintenance Manual section applicable to the system under review. For Airbus, non-destructive testing of the system wiring is included in the ESPM.	(a) Task 7 (b)(c) OEMs
	3b3 Aircraft Manufacturers: Develop design modification to minimize potential for contamination. Incorporation Plan: OEMs - Potential sources of contamination of airplane wiring are identified by OEMs during the design and development of the airplane, and appropriate protection in the form of drip or heat shields are included to minimize the effects of contamination. When unanticipated sources of contamination are identified during service operation, additional protection is specified and available to operators through a service letter or service bulletin. In the case of general protection of wiring during unrelated maintenance, OEMs will provide protection guidelines in future revisions to their ESWPM.	OEMs

Boeing is presently evaluating several methods of maintenance protection in various areas of an airplane. These recommendations must be validated with operators and repair stations before they are implemented into the SWPM. At this time a definitive schedule is not available.

The Airbus ESPM currently provides guidelines for the cleaning of EWIS components (Chapter 20-55-00) and protection (Chapter 20-54-00) during maintenance. Any HWG7 and HWG9 recommendations will be analyzed and included if appropriate

In addition, based upon the ATSRAC and FAA recommendations that we do so, the OEMs are presently implementing notes into all service bulletins cautioning operators about the importance of protecting wiring during maintenance. Boeing implemented service bulletins incorporating this note in mid-2002.

Airbus has launched corresponding actions to implement the EAPAS recommendation to include information in service data on minimizing wiring contamination during maintenance. A dedicated procedure is presently under preparation for introduction in the next available revision of the ESPM. This task will cover the recommendations and information included in ATA Specification 117. We are investigating also the possibility to introduce this Task in the AMM. As soon as this specific Task will be available, a cross-reference to the ESPM or AMM will be made in all relevant Service Bulletins

Lockheed has been adding notes to its SB's recommending the utilization ATA Specification 117 guidelines when performing maintenance in, on or around wiring. All L-1011 operators have been supplied a copy of the specification and are urged to implement it into their maintenance programs. The revision of the LMCO SWPM will provide reference to ATA Specification 117. Additionally, review of our Maintenance Manuals shows that more notes should be added, regarding, regarding proper techniques and the use of suggested references.

3b4 Other: Develop an understanding of how vibration and contamination (solid and liquid) interact. FAA

Incorporation Plan:

	A contract to complete Phase II (Testing) and Phase III (Analysis of Test Results) has been awarded to Raytheon Technical Services Company (RTSC). RTSC, Brookhaven National Labs, Sandia National Labs, and Lectromech, will conduct extensive wire testing in support of this project.	
Situation	**Recommendations**	
3c. Multiple critical systems, arc tracking potential	Given the specified conditions, the occurrence of this fault could lead to potentially critical consequences. Wire chafing with arc tracking potential and wires from critical systems in close proximity could result in arcing and propagation to other wires, smoke and/or fire, and loss of multiple critical systems which can lead to excessive crew workload.	OWNER
	3c1 Task Group 3: (a) Specify guidelines to ensure the proper attention to protection and cleaning wire bundles. (b)Develop guidance to ensure the proper attention to protection of wire bundles. Incorporation Plan Summary: HWG7 - (a) General and conditional wiring protection and cleaning procedures will be included in the SWPM/ESPM as minimum content. HWG6 - (b) has drafted new rules on this subject (25.1703, 25.1705, and 25.1709), and corresponding advisory material in the new AC/ACJ for EWIS. See HWG6 Final Report, Appendices A, B and D.	(b) Task 6 (a) Task 7
	3c2 Task Group 4: (a) Specify situation-specific standards to ensure wire bundles are securely fastened and out of harm's way. (b) Develop situation specific wiring separation guidelines that consider loss of multiple critical functions from a common mode failure. (c) Specify nondestructive testing procedures for validating wire integrity in response to undiagnosed electrical malfunctions. Incorporation Plan: OEM's - (a)(c) Wire attachment guidelines are presently contained within the ESWPM and reflect current production design standard that account for loss of multiple or redundant systems. Any changes to the standards will be reflected in future revisions to the ESWPM. Troubleshooting procedures to determine the cause of any system malfunction or anomaly, including non-destructive troubleshooting of the system wiring, is contained within the specific Airplane Maintenance Manual section applicable to the system under review. For Airbus, non-destructive testing of the system wiring is included in the ESPM. Any new testing methods that arise (e.g. HWG 9 recommendations)	(a) OEMs (b) Task 6 (c) OEMs

	will be analyzed and included if appropriate. It is the responsibility of each operator to ensure that inspection guidelines are incorporated into their maintenance programs HWG6 - (b) has drafted new rules on this subject (25.1705 and 25.1709), and corresponding advisory material in the new AC/ACJ for EWIS. See HWG6 Final Report, Appendices A, B, and D.	
Situation	**Recommendations**	
3d. Flammable materials	Given the specified conditions, the occurrence of this fault could lead to potentially severe consequences. Wire chafing in the presence of flammable materials can lead to arcing, smoke and /or in-flight fire and increased crew workload. Augmenting general visual inspection with a detailed or directed visual inspection in critical areas can mitigate this condition. Emphasis on minimizing flammable materials in close proximity to wiring can mitigate this condition.	OWNER
	3d1 Task Group 3: Specify guidelines on the separation of wire bundles from non-fire-retardant materials. Incorporation Plan: HWG6 - HWG6 has drafted new rules on this subject (25.1703, 25.1705, and 25.1709), and corresponding advisory material in the new AC/ACJ for EWIS. See HWG6 Final Report, Appendices A, B, and D.	Task 6
Situation	**Recommendations**	
3e. Contamination	Given the specified conditions, the occurrence of this fault could lead to potentially severe consequences. Wire chafing in the presence of contamination can lead to arcing, smoke and /or localized. Augmenting general visual inspection with a detailed or directed visual inspection in critical areas can mitigate this condition. Emphasis on cleaning of contaminants can mitigate the risk of enhanced flammability and aids in the inspection process.	OWNER
	3e1 Task Group 4: Specify enhanced standards to ensure that these wire bundles are properly protected and cleaned. Incorporation Plan: HWG7 - General and conditional wiring protection and cleaning procedures will be included in the ESWPM as minimum content.	Task 7

3e2 Aircraft Manufacturer: Consider design modification to minimize potential for contamination. OEMsTask 6

Incorporation Plan:

OEMs - Potential sources of contamination of airplane wiring are identified by OEMs during the design and development of the airplane, and appropriate protection in the form of drip or heat shields are included to minimize the effects of contamination. When unanticipated sources of contamination are identified during service operation, additional protection is specified and available to operators through a service letter or service bulletin. In the case of general protection of wiring during unrelated maintenance, OEMs will provide protection guidelines in future revisions to their ESWPM.

Boeing is presently evaluating several methods of maintenance protection in various areas of an airplane. These recommendations must be validated with operators and repair stations before they are implemented into the SWPM. At this time a definitive schedule is not available.

The Airbus ESPM currently provides guidelines for the cleaning of EWIS components (Chapter 20-55-00) and protection (Chapter 20-54-00) during maintenance. Any HWG7 and HWG9 recommendations will be analyzed and included if appropriate

In addition, based upon the ATSRAC and FAA recommendations that we do so, the OEMs are presently implementing notes into all service bulletins cautioning operators about the importance of protecting wiring during maintenance. Boeing implemented service bulletins incorporating this note in mid-2002. Airbus has launched corresponding actions to implement the EAPAS recommendation to include information in service data on minimizing wiring contamination during maintenance. A dedicated procedure is presently under preparation for introduction in the next available revision of the ESPM. This task will cover the recommendations and information included in ATA Specification 117. We are investigating also the possibility to introduce this Task in the AMM. As soon as this specific Task will be available, a cross-reference to the ESPM or AMM will be made in all relevant Service Bulletins.

Lockheed has been adding notes to its SB's recommending the utilization ATA Specification 117 guidelines when performing maintenance in, on or around wiring. All L-1011 operators have been supplied a copy of the specification and are urged to implement it into their maintenance programs. The revision of the LMCO SWPM will provide reference to

	ATA Specification 117. Additionally, review of our Maintenance Manuals shows that more notes should be added, regarding proper techniques and the use of suggested references. HWG6 - HWG6 has drafted new rules on this subject (25.1703, 25.1705, 25.1709), and corresponding advisory material in the new AC/ACJ for EWIS. See HWG6 Final Report, Appendices A, B, and D.	
	3e3 Other: Develop and understanding of how vibration and contamination (solid and liquid) interact. Incorporation Plan: A contract to complete Phase II (Testing) and Phase III (Analysis of Test Results) has been awarded to Raytheon Technical Services Company (RTSC). RTSC, Brookhaven National Labs, Sandia National Labs, and Lectromech, will conduct extensive wire testing in support of this project.	FAA
Situation	**Recommendations**	
3f. Multiple critical systems	Given the specified conditions, the occurrence of this fault could lead to potentially severe consequences. Wire chafing with wires from critical systems in close proximity can lead to arcing and loss of multiple critical systems and increased crew workload. Augmenting general visual inspection with a detailed or directed visual inspection for bundles with multiple critical systems can mitigate this condition. Maintaining wiring separation for critical and redundant systems can mitigate the risk of multiple system failures.	OWNER
	3f1 Task Group 4: Specify situation-specific separation and segregation guidelines specifically for this situation. Incorporation Plan: HWG6 - HWG6 has drafted new rules on this subject (25.1703, 25.1705, 25.1709), and corresponding advisory material in the new AC/ACJ for EWIS. See HWG6 Final Report, Appendices A, B, and D.	Task 6
Situation	**Recommendations**	
3g. Feeder cable	Given the specified conditions, the occurrence of this fault could lead to potentially severe consequences. Chafing of a primary power feeder cable can lead to loss of a primary power source and violent arcing with damage to other systems and structure. Augmenting general visual inspection with a detailed or directed visual inspection (emphasizing the special requirements for integrity and	OWNER

	configuration of power feeder cables) can mitigate this condition. Nondestructive testing can detect wire chafing (after significant dielectric breakdown) and aid in expedient repair. Because there are relatively few power feeder cables, more sophisticated testing is practical and should be specified.	
	3g1 Task Group 3: Specify more detailed inspection and testing to ensure potential chafing problems are spotted and corrected. Incorporation Plan: HWG9 - MSG3 Rev 2001.1 EZAP logic includes a detailed listing of "Details of Zone", where installed equipment, wire bundles, possible combustible materials present, L/HIRF protection features, etc., are determined as a prerequisite to conducting Zonal Analysis of a zone. Due to their high current potential and ease of identification (size), presence of feeder cables should be specifically noted in the list of details in a zone and considered for Detailed Inspection based on zone environment and frequency of maintenance access to the zone where potential damage could occur. Use of non-destructive testing is insufficiently mature to apply on a scheduled basis. Initially, new NDT methods would likely be used to support trouble-shooting activities, which will provide the necessary experience to allow assessment of their use in scheduled maintenance.	Task 9
	3g2 Task Group 4: (a) Establish specific nondestructive testing protocols for power feeder cable. (b) Establish enhanced separation requirements specifically for this situation. Incorporation Plan: HWG6 - (a) Task Group 6 believes that this is not part of Task 6 charter. Task Group 6 recommends that this be handled by FAA R&D Group. FAA comments: As part of its Aging Electrical Systems Research Program, the FAA is currently conducting research on non-destructive inspection (NDI) and non-destructive test (NDT) methods for the inspection of the EWIS system. Numerous technologies are being researched and evaluated. A standard wiring test bed has been established at Sandia National Labs to aid in the development and testing of NDI/NDT equipment. All validation efforts will include (as applicable) test and evaluation of the NDI/NDT technique on power feeders. Results of the NDI/NDT program will be	(a) Task 6 (b) OEMs/Task 6

	publicly disseminated. (b) Airbus/Boeing - Routing, separation and attachment guidelines unique to airplane power feeder cables is presently available in the ESWPM. Lockheed - currently the ESWPM provides wire bundle maintenance guidelines but does not specifically provide guidelines for power feeder cables. LMCO will develop specific maintenance practices for power feeder cables and incorporate them into the ESWPM at the next revision HWG6 - (b) HWG6 has drafted a new rule on this subject (25.1709), and corresponding advisory material in the new AC/ACJ for EWIS. See HWG6 Final Report, Appendices A, B, and D.	
	3g3 Aircraft Operators: Ensure awareness of best-practice considerations for feeder cables. Incorporation Plan: HWG7 - Proper installation and maintenance of electrical power feeder cables will be included in the SWPM/ESPM minimum content. FAA - Non-destructive inspection of power feeders white paper prepared and delivered to Working Group Nine. Separation and segregation research will consider power feeders (see action item number 2e4).	Task 7 FAA
Table 7-5-4: Cracked Insulation		
Situation	**Recommendations**	
4. Any situation involving one or more of the conditions identified below.	This finding is relatively common. Concentrations of cracks (through to the conductor) may under special circumstances result arcing or shorting. Visual inspection cannot be relied upon to detect cracks directly, and while testing technologies can detect certain bulk changes in insulation properties, there is no reliable and convenient means of identifying cracks. An AFCB can mitigate this condition by minimizing damage and preventing electrical fire.	OWNER
	4.1 Aircraft Manufacturers: Continue development of arc-fault circuit breaker technology. Develop generic implementation plans for the potential retrofit of arc-fault circuit breakers onto in-service aircraft. Incorporation Plan:	OEMs

	(b) Boeing/Airbus - Implementation of any new technology will be evaluated as it is being developed and with the input of the operators. Lockheed - as AFCB technology is developed LMCO will continue to evaluate, with operators, the applicability for individual systems. If found effective the OEMs will encourage the adoption of the technology.	
	4.2 Aircraft Operators: Develop generic implementation plans for the potential retrofit of arc-fault circuit breakers onto in-service aircraft. Incorporation Plan: (b) Boeing/Airbus - Implementation of any new technology will be evaluated as it is being developed and with the input of the operators. Lockheed - as AFCB technology is developed LMCO will continue to evaluate, with operators, the applicability for individual systems. If found effective the OEMs will encourage the adoption of the technology.	OEMs
	4.3 Other: Research and develop nondestructive testing techniques capable of identifying and locating insulation cracks. Consider using these techniques for both inspection and troubleshooting of suspect wires. Consider utilization of such techniques to establish on-condition criteria for replacement of endemic cracking wire. Incorporation Plan: Boeing/Airbus are presently conducting testing of wiring removed from service airplanes with the intent of identifying NDT techniques to replace suspect wiring. This testing is ongoing and may result in the identification of and limits to insulation cracking. Lockheed - as new technology is developed LMCO will evaluate and recommend the use of proven, viable techniques in an effort to improve the detection of suspect wiring.	OEMs
Situation	**Recommendations**	
4a. Flammable materials. Cockpit or electronics bay	Given the specified conditions, the occurrence of this fault could lead to potentially critical consequences. Though moisture may or may note be present in the scenario, the specified zones and installation within these zones are critical enough to warrant extra care and precaution. If visual inspection is used, it should be supplemented by the removal of flammable materials from these locations.	OWNER
	4a1 Task Group 3: Specify accelerated removal of flammable materials.	Task 7

	Incorporation Plan Summary: HWG7 - General and conditional cleaning procedures will be included in the ESWPM as minimum content.	
	4a2 Task Group 3: Consider local design modification to replace non-fire-retardant materials. Incorporation Plan: Specification and use of materials in the manufacture of an airplane, especially the ability of the material to self-extinguish, comply with federal regulations at the time of certification. Service experience or a change in the use of the airplane would be used to determine whether an original material should be replaced by a material meeting a different flammability standard. Use of the term "non-fire retardant materials" refers to an assessment of the flammability of the materials used in the construction of the airplane. FARs 25.853 and 25.851 provide flammability standards. In addition, There are several ongoing studies aimed at reducing or eliminating the use of flammable materials in the flight deck and E/E bay areas, one of which is an ARAC. The OEMs will actively participate in these studies in order to identify acceptable materials, and will consider use of these materials in present and future airplanes. Removal of materials thought to degrade the operational safety of an airplane is an appropriate response whereas removal of materials meeting a different standard from that currently in place for new airplane designs is not.	OEMs
	4a3 Aircraft Operators: Accelerate removal of flammable materials from the cockpit and electronics bay. Incorporation Plan: ARAC/FAA - Airworthiness Directives have been issued for the metalized mylar insulation	ARAC/FAA
	4a4 Other: Research and develop fire retarding and suppressing materials and systems for cockpit or electronics bay use. Incorporation Plan: Airbus/Boeing - There are several ongoing studies aimed at reducing or eliminating the use of non-fire retardant materials in the flight deck and E/E bay areas, one of which is an ARAC. Boeing will actively participate in these studies in order to identify acceptable materials, and will consider	OEMs

	use of these materials in present and future airplanes. Lockheed - materials met the current FAA flammability requirements at the time of design.	
Situation	**Recommendations**	
4b. Moisture, flammable materials, multiple critical systems	Given the specified conditions, the occurrence of this fault could lead to potentially critical consequences. The potential for fire and multiple critical system failures exists. Multiple cracks in a localized area of a bundle serving multiple critical systems can also result in stray currents, which adversely affect the functionality of those systems. If visual inspection is used, it should be supplemented by efforts to eliminate the potential for moisture intrusion and the removal of flammable materials. Maintaining wiring separation for critical and redundant systems can mitigate the risk of multiple system failures.	OWNER
	4b1 Task Group 3: Specify accelerated removal of flammable materials. Specify guidelines to minimize moisture intrusion into wire bundles (e.g. specify drip shields over bundles running under lavatories). Specify guidelines to minimize moisture accumulation on or near bundles. Incorporation Plan: Use of the term "flammable materials" refers to the accumulation of contaminants over time rather than an assessment of the flammability of the materials used in the construction of the airplane Prevention of contamination, and cleaning of noted contamination on the exterior of wiring will be included in the manufacturers ESWPM. Procedures for the use of drip loops and other moisture prevention techniques as methods of prevention for moisture ingression into connectors or wiring is presently outlined in the ESWPM. For Boeing, additional guidelines for the removal of moisture accumulations within the airplane as a whole are contained within the specific AMM chapter applicable to the system or zone under review. The results of the ongoing studies aimed at identifying and eliminating the use of flammable materials in the flight deck and E/E bay areas, will determine the any further OEM action required. The OEMs support the prompt removal of flammable contaminants and recommend that operators do so and provide effective procedures for doing so. However, we do not support the identification and removal of materials that meet flammability requirements and which do not degrade the operational safety of the airplane. Removal of materials thought to degrade the operational safety of an airplane is	OEMs

	an appropriate response whereas removal of materials meeting a different standard from that currently in place for new airplane designs is not.	
	4b2 Task Group 4: Specify situation-specific wiring separation and segregation guidelines that consider loss of multiple critical functions from a common mode failure. Incorporation Plan: Wire separation and segregation guidelines are presently contained within the manufacturer's ESWPM and reflect current production design standard that account for loss of multiple or redundant systems. An assessment of the current wiring separation and segregation guidelines provided by the OEMs indicate that they already account for loss of multiple critical functions as a result of a common mode failure, so no changes were necessary to the guidelines to comply with the recommendation. HWG6 - (b) HWG6 has drafted new rules on this subject (25.1705, 25.1709, and 25.1711), and corresponding advisory material in the new AC/ACJ for EWIS. See HWG6 Final Report, Appendices A, B, and D.	OEMs
	4b3 Aircraft Manufacturers: Consider design modification to enhance wire separation requirements for this specific situation. Consider local design modification to replace non-fire-retardant materials. Incorporation Plan Summary: HWG 6 - Separation of EWIS components from various airplane systems such as fuel systems, oxygen systems and others are covered by the new FAR/JARs 25.1705, 25.1709, and 25.1711 requirements and the new AC/ACJ for EWIS. See HWG6 Final Report, Appendices A, B, and D.	Task 6
	4b4 Aircraft Operators: Accelerate removal of flammable materials. Incorporation Plan: Use of the term "flammable materials" refers to the accumulation of contaminants over time rather than an assessment of the flammability of the materials used in the construction of the airplane Removal of materials thought to degrade the operational safety of an airplane is an appropriate response whereas removal of materials meeting a different standard from that currently in place for new airplane designs is not. Prevention	OEMs

	of contamination, and cleaning of noted contamination on the exterior of wiring will be included in the manufacturers ESWPM. Procedures for the use of drip loops and other moisture prevention techniques as a method of prevention for moisture ingression into connectors or wiring is presently outlined in the ESWPM. For Boeing, additional guidelines for the removal of moisture accumulations within the airplane as a whole are contained within the specific AMM chapter applicable to the system or zone under review. The results of the ongoing studies aimed at identifying and eliminating the use of flammable materials in the flight deck and E/E bay areas, will determine the any further OEM action required. The OEMs support the prompt removal of flammable contaminants and recommend that operators do so and provide effective procedures for doing so. However, we do not support the identification and removal of materials that meet flammability requirements and which do not degrade the operational safety of the airplane.	
	4b5 Other: Research and develop fire retarding and suppressing materials and systems suitable for this situation.. Incorporation Plan: A request has been sent to the FAA Fire Research Program for consideration of the recommended action. The Aging Electrical Systems Research Program and Fire Research Program will coordinate an appropriate response.	FAA
Situation	**Recommendations**	
4c. Moisture, flammable materials	Given the specified conditions, the occurrence of this fault could lead to potentially severe consequences. If visual inspection is used, it should be supplemented by efforts to eliminate the potential for moisture intrusion and the removal of flammable materials.	OWNER
	4c1 Task Group 3: Specify guidelines to minimize moisture intrusion. Specify guidelines to minimize moisture accumulation on or near bundles. Moisture intrusion prevention is presently taken into consideration during the design of the electrical system. Procedures for the use of drip loops and other moisture prevention techniques as a method of prevention for moisture ingression into connectors or wiring is presently outlined in the Boeing and Lockheed ESWPM's. Airbus will include in the ESPM guidance and practices to maintain the design provisions for the prevention of moisture contamination to wiring. For Boeing airplanes, additional	OEMs

guidelines for the removal of moisture accumulations within the airplane as a whole are contained within the specific AMM chapter applicable to the system or zone under review.

The presence of contamination may affect the operation of the system, definitely affects the ability to assess the condition of airplane wiring, and increases both unscheduled and schedule maintenance costs. Potential sources of contamination of airplane wiring are identified during the design and development of the airplane, and appropriate protection in the form of drip or heat shields are included to minimize the effects of contamination. If in-service experience shows that additional protection against contamination is required, then a design modification will be developed to provide additional protection. This will be made available to operators thru a service bulletin, recommending the incorporation of drip shields, heat shields, drains, etc. In the case of general protection of wiring during unrelated maintenance, OEMs will provide protection guidelines in an upcoming revision to the ESWPM.

	4c2 Aircraft Operators: Accelerate removal of flammable materials. Incorporation Plan: Use of the term "flammable materials" refers to the accumulation of contaminants over time rather than an assessment of the flammability of the materials used in the construction of the airplane Removal of materials thought to degrade the operational safety of an airplane is an appropriate response whereas removal of materials meeting a different standard from that currently in place for new airplane designs is not. Prevention of contamination, and cleaning of noted contamination on the exterior of wiring will be included in the manufacturers ESWPM. For Boeing, additional guidelines for the removal of accumulations of flammable materials are contained within the specific AMM chapter applicable to the system or zone under review. The results of the ongoing studies aimed at identifying and eliminating the use of flammable materials in the flight deck and E/E bay areas, will determine if any further OEM action is required. OEMs support the prompt removal of flammable contaminants provide effective procedures for doing so. However, they do not support the identification and removal of materials, which meet flammability requirements and do not degrade the operational safety of the airplane.	OEMs

Situation	**Recommendations**

4d. Moisture, multiple critical systems	Given the specified conditions, the occurrence of this fault could lead to potentially severe consequences. The potential for multiple critical system failures exists. Multiple cracks in a localized area of a bundle serving multiple critical systems can also result in stray currents, which adversely affect the functionality of those systems. If visual inspection is used, it should be supplemented by efforts to eliminate the potential for moisture intrusion.	OWNER
	4d1 Task Group 3: Specify guidelines to minimize moisture intrusion. Specify guidelines to minimize moisture accumulation on or near bundles. Incorporation Plan: Moisture intrusion prevention is presently taken into consideration during the design of the electrical system. Procedures for the use of drip loops and other moisture prevention techniques as a method of prevention for moisture ingression into connectors or wiring is presently outlined in the Boeing and Lockheed ESWPM's. Airbus will include in the ESPM guidance and practices to maintain the design provisions for the prevention of moisture contamination to wiring; for Boeing airplanes, additional guidelines for the removal of moisture accumulations within the airplane as a whole are contained within the specific AMM chapter applicable to the system or zone under review. The presence of contamination may affect the operation of the system, definitely affects the ability to assess the condition of airplane wiring, and increases both unscheduled and schedule maintenance costs. Potential sources of contamination of airplane wiring are identified during the design and development of the airplane, and appropriate protection in the form of drip or heat shields are included to minimize the effects of contamination. If in-service experience shows that additional protection against contamination is required, then a design modification will be developed to provide additional protection. This will be made available to operators thru a service bulletin, recommending the incorporation of drip shields, heat shields, drains, etc. In the case of general protection of wiring during unrelated maintenance, OEMs will be providing protection guidelines in an upcoming revision to the ESWPM. HWG6 – HWG6 has drafted a new rule on this subject (25.1703), and corresponding advisory material in the new AC/ACJ for EWIS. See HWG6 Final Report, Appendices A, B, and D.	OEMs Task 6

Situation	Recommendations	
4e. Contamination, multiple critical systems	Given the specified conditions, the occurrence of this fault could lead to potentially severe consequences. Concentrations of cracks (through to the conductor) can (in the presence of some conductive contaminant) result arcing or shorting. Though flammable materials may or may not be present in this scenario, the potential for combustion (with flammable contaminants) or multiple critical system failures exists. In addition, multiple cracks in a localized area of a bundle serving multiple critical systems can also result in stray currents, which adversely affect the functionality of those systems. If visual inspection is used, it should be supplemented by efforts to eliminate the potential for contamination (i.e. drip or splatter shields).	OWNER
	4e1 Task Group 4: Develop enhanced standards to ensure that these wire bundles are properly protected and cleaned. Incorporation Plan: HWG6 - has drafted a new rule on this subject (25.1703, 25.1705, 25.1709, and 25.1711), and corresponding advisory material in the new AC/ACJ for EWIS. See HWG6 Final Report, Appendices A, B, and D. HWG9 - MSG3, Rev 2001.1 EZAP logic includes a determination if accumulation of combustible material likely in a zone, and selection of task(s) to prevent significant accumulation of combustible material.	Task 6/9
	4e2 Aircraft Manufacturers: Consider design modification to minimize potential for contamination. Incorporation Plan: The presence of contamination may affect the operation of the system, definitely affects the ability to assess the condition of airplane wiring, and increases both unscheduled and schedule maintenance costs. Potential sources of contamination of airplane wiring are identified during the design and development of the airplane, and appropriate protection in the form of drip or heat shields are included to minimize the effects of contamination. If in-service experience shows that additional protection against contamination is required, then a design modification will be developed to provide additional protection. This will be made available to operators thru a service bulletin, recommending the incorporation of drip shields, heat shields, drains, etc. In the case of general protection of wiring during unrelated maintenance, OEMs will provide protection guidelines in an upcoming revision to the ESWPM.	OEMs

Situation	Recommendations	
4f. Flammable materials, multiple critical systems, vibration	Given the specified conditions, the occurrence of this fault could lead to potentially severe consequences. Concentrations of large cracks (through to the conductor) can (if brought into physical contact by vibration) result arcing or shorting. In addition, vibration of cracked insulation can accelerate the degeneration of this condition. The potential for combustion or multiple critical system failures exists. In addition, multiple cracks in a localized area of a bundle serving multiple critical systems can also result in stray currents, which adversely affect the functionality of those systems. If visual inspection is used, it should be supplemented by efforts to minimize exposure to flammable materials. Additional security (clamps, ties, etc) should be used to reduce the potential for accelerated damage and failure.	OWNER
	4f1Task Group 3: Specify accelerated removal of flammable materials. Establish guidelines to ensure, and enhance where necessary, the secure installation of wire bundles. Incorporation Plan: Use of the term "flammable materials" refers to the accumulation of contaminants over time rather than an assessment of the flammability of the materials used in the construction of the airplane OEMs support the prompt removal of flammable contaminants provide effective procedures for doing so. However, they do not support the identification and removal of materials, which meet flammability requirements and do not degrade the operational safety of the airplane. Prevention of contamination, and cleaning of noted contamination on the exterior of wiring will be included in the manufacturers ESWPM. In addition, specific unique procedures for the attachment and prevention of damage to wiring in high vibration areas are presently provided in the ESWPM.	OEMs
	4f2Aircraft Operators: Accelerate removal of flammable materials in suspect areas. Incorporation Plan: Use of the term "flammable materials" refers to the accumulation of contaminants over time rather than an assessment of the flammability of the materials used in the construction of the airplane.	OEMs

	OEMs support the prompt removal of flammable contaminants provide effective procedures for doing so. However, they do not support the identification and removal of materials, which meet flammability requirements and do not degrade the operational safety of the airplane. Removal of materials thought to degrade the operational safety of an airplane is an appropriate response whereas removal of materials meeting a different standard from that currently in place for new airplane designs is not. Prevention of contamination, and cleaning of noted contamination on the exterior of wiring will be included in the manufacturers ESWPM. For Boeing, additional guidelines for the removal of accumulations of flammable materials are contained within the specific AMM chapter applicable to the system or zone under review. The results of the ongoing studies aimed at identifying and eliminating the use of flammable materials in the flight deck and E/E bay areas, will determine if any further OEM action is required. Airbus/Boeing - Prevention of contamination, and cleaning of noted contamination on the exterior of wiring will be included in the Boeing ESWPM. Lockheed - Expanded requirements for the cleaning of and prevention of contamination will be included in the revision to the ESWPM.	

Table 7-5-5: Delamination		
Situation	**Recommendations**	
5. Any situation involving one or more of the conditions identified below	This finding is relatively infrequent. Delaminations (through to the conductor) may under special circumstances result arcing or shorting. Visual inspection may not be able to detect delamination. (Data on the visual detect ability of delamination is very limited.) If visual inspection is used, it should be supplemented by efforts to eliminate the potential for moisture intrusion and efforts to minimize exposure to flammable materials. An AFCB can mitigate this condition by minimizing damage and preventing electrical fire.	OWNER
	5.1 Task Group 3: Specify guidelines that precipitate an invasive inspection or nondestructive testing of wire bundles exposed to suspected high or low pH contaminants. Specify guidelines for decontamination procedures for wire to neutralize the effects of chemically aggressive contaminants. Incorporation Plan:	OEMs

	Guidelines for the cleaning and conditional inspection of contaminated wiring will soon be included in the Boeing/Lockheed ESWPM (and in the Maintenance Planning Document for Boeing airplanes) applicable to the specific model airplane. Additionally, Lockheed will re-issue a SIL that addresses the cleaning of contaminants from wiring. The Airbus ESPM currently gives guidelines for the cleaning, protection and inspection of wiring. Although they do not assess the acidity or alkalinity of contaminants, present guidelines regarding the cleaning and/or repair of wiring account for the wide pH range of possible contaminants.	
	5.2 Aircraft Manufacturers: Continue development of arc-fault circuit breaker technology. Develop generic implementation plans for the potential retrofit of arc-fault circuit breakers onto in-service aircraft. Incorporation Plan: Boeing/Airbus - Implementation of any new technology will be evaluated as it is being developed and with the input of the operators. Lockheed - as AFCB technology is developed LMCO will continue to evaluate, with operators, the applicability for individual systems. If found effective the OEMs will encourage the adoption of the technology.	OEMs
	5.3 Operators: Specify maintenance procedures and training to instruct technicians on use of techniques to identify suspect wires. Incorporation Plan: HWG8 - Maintenance procedures are discussed in Wire Module E6: Maintenance and Repair Procedures. Techniques of identifying suspect wires are covered in Wire Module E5: Typical Damage and Areas Found (airplane specific).	Task 8
	5.4 Other: (a) Specify use of in-situ indicators to identify exposure to precipitating agents or conditions – a “canary”. (In particular, use in-situ litmus testing to identify exposure of wrapped construction wire to high or low pH solutions or contaminants.) (b) Develop updated wiring separation guidelines that consider loss of multiple critical functions from a common mode failure. Incorporation Plan: OEMs	OEMs Task 6

	(a) Boeing and Lockheed - guidelines for the cleaning and conditional inspection of contaminated wiring will be included in a future revision to the ESWPM and Maintenance Planning Document applicable to the specific model airplane. The Airbus ESPM currently gives guidelines for the cleaning, protection and inspection of wiring. Additionally, Lockheed will re-issue a SIL that addresses the cleaning of contaminants from wiring. OEMs account for the environment in which wiring is expected to operate and specify wiring and components suitable for that environment. The OEMs believe that the process of a detailed visual examination, determining whether contamination exists or existed previously, whether wiring damage resulted from that contamination, procedures for the removal of contamination regardless of the pH, and repair of wiring damage, precludes the need to install additional insitu indications of contamination at various locations throughout the airframe. (b) HWG6 - has drafted new rules on this subject (25.1705, 25.1709, and 25.1711), and corresponding advisory material in the new AC/ACJ for EWIS. See HWG6 Final Report, Appendices A, B, and D.	
Situation	**Recommendations**	
5a. Flammable materials, cockpit or electronics bay	Given the specified conditions, the occurrence of this fault could lead to potentially critical consequences. Though moisture may or may not be present in this scenario, the specified zones and installations within these zones are critical enough to warrant extra care and precaution.	OWNER
	5a1 Aircraft Manufacturers: Consider design modification to eliminate non-fire-retardant materials. Incorporation Pan Use of the term "flammable materials" refers to the accumulation of contaminants over time rather than an assessment of the flammability of the materials used in the construction of the airplane Removal of materials thought to degrade the operational safety of an airplane is an appropriate response whereas removal of materials meeting a different standard from that currently in place for new airplane designs is not. Prevention of contamination, and cleaning of noted contamination on the exterior of wiring will be included in the manufacturers ESWPM. For Boeing, additional guidelines for the removal of accumulations of flammable materials are contained within	OEMs

	the specific AMM chapter applicable to the system or zone under review. The results of the ongoing studies aimed at identifying and eliminating the use of flammable materials in the flight deck and E/E bay areas, will determine if any further OEM action is required. OEMs support the prompt removal of flammable contaminants provide effective procedures for doing so. However, they do not support the identification and removal of materials, which meet flammability requirements and do not degrade the operational safety of the airplane.	
	5a2 Operators: Accelerate removal of flammable materials. Incorporation Plan: Use of the term "flammable materials" refers to the accumulation of contaminants over time rather than an assessment of the flammability of the materials used in the construction of the airplane. Removal of materials thought to degrade the operational safety of an airplane is an appropriate response whereas removal of materials meeting a different standard from that currently in place for new airplane designs is not. Prevention of contamination, and cleaning of noted contamination on the exterior of wiring will be included in the manufacturers ESWPM. For Boeing, additional guidelines for the removal of accumulations of flammable materials are contained within the specific AMM chapter applicable to the system or zone under review. The results of the ongoing studies aimed at identifying and eliminating the use of flammable materials in the flight deck and E/E bay areas, will determine if any further OEM action is required. OEMs support the prompt removal of flammable contaminants provide effective procedures for doing so. However, they do not support the identification and removal of materials which meet flammability requirements and do not degrade the operational safety of the airplane	OEMs
Table 7-5-6: Arcing		
Situation	**Recommendations**	
6. Any situation involving one or more of the conditions identified below.	This finding is relatively infrequent. Arcing can result from degraded or damaged wire or non-environmental or degraded splices. Because visual inspection will probably not detect initial arcing, efforts should focus on minimizing wire exposure to chafing, traumatic impact during maintenance operation in the area. Use of environmental	OWNER

	splices can reduce the potential for a hazardous arc. Use of an AFCB can mitigate the consequences of arcing. Operational procedures, including Flight Standards Information Bulletin 00/08A, can also mitigate the consequences of initial failure.	
	6.1 Task Group 5: Develop guidelines that ensure that all maintenance personnel, not just electrical maintenance technicians, are made aware of those actions that could result in breached wire. Small breaches (such as those resulting from the needling of wire) should not be dismissed as inconsequential. Incorporation Plan: HWG8 - Guidelines for all maintenance personnel to prevent insulation breaches of airplane wire are found in Housekeeping Module D5: Protection During Airplane Maintenance and Repair. The dangers of needling wire (insertion of probes through insulation) are covered in Introduction Module A6; Measurement and Troubleshooting Using Meters and Wire Module E2; Insulation Qualities.	Task 8
	6.2 Aircraft Manufacturers: Continue development of arc-fault circuit breaker technology. Develop generic implementation plans for the potential retrofit of arc-fault circuit breakers onto in-service aircraft. Incorporation Plan: Boeing/Airbus - Implementation of any new technology will be evaluated as it is being developed and with the input of the operators. Lockheed - as AFCB technology is developed LMCO will continue to evaluate, with operators, the applicability for individual systems. If found effective the OEMs will encourage the adoption of the technology.	OEM's
	6.3 Operators: (a) Develop generic implementation plans for the potential retrofit of arc-fault circuit breakers onto in-service aircraft. (b) Make maintenance personnel aware of the dangers of arcing. Incorporation Plan: Boeing/Airbus - (a) Implementation of any new technology will be evaluated as it is being developed and with the input of the operators. Lockheed - as AFCB technology is developed LMCO will continue to evaluate, with operators, the applicability for individual systems. If found effective the OEMs will encourage the adoption of the technology.	(a) OEMs (b) Task 8

	HWG8 - (b) Arcing is covered in Wire Module E2 (c): Carbon arcing.	
	6.4 Other: Continue research necessary to support the development of arc-fault circuit breakers and incorporate AFCB into other circuit switching devices and selected electrical components. Conduct research into other technologies that mitigate the risk of arcing. Incorporation Plan: Boeing/Airbus - Implementation of any new technology will be evaluated as it is being developed and with the input of the operators. Lockheed - as AFCB technology is developed LMCO will continue to evaluate, with operators, the applicability for individual systems. If found effective the OEMs will encourage the adoption of the technology.	OEMs
Situation	**Recommendations**	
6a. Flammable materials, cockpit or electronics bay	Given the specified conditions, the occurrence of this fault could lead to potentially critical consequences. The existence of an arcing condition in the presence of flammable materials is unacceptable. The cockpit and electronics bay warrant special attention. Elimination of flammable materials can mitigate the consequences of arcing.	OWNER
	6a1 Operators: Accelerate removal of flammable materials from the cockpit and electronics bay. Incorporation Plan: Use of the term "flammable materials" refers to the accumulation of contaminants over time rather than an assessment of the flammability of the materials used in the construction of the airplane Removal of materials thought to degrade the operational safety of an airplane is an appropriate response whereas removal of materials meeting a different standard from that currently in place for new airplane designs is not. Prevention of contamination, and cleaning of noted contamination on the exterior of wiring will be included in the manufacturers ESWPM. For Boeing, additional guidelines for the removal of accumulations of flammable materials are contained within the specific AMM chapter applicable to the system or zone under review. The results of the ongoing studies aimed at identifying and eliminating the use of flammable materials in the flight deck and E/E bay areas, will determine if any further OEM action is required.	OEMs

	OEMs support the prompt removal of flammable contaminants provide effective procedures for doing so. However, they do not support the identification and removal of materials which meet flammability requirements and do not degrade the operational safety of the airplane	
Situation	**Recommendations**	
6b. Flammable materials, multiple critical systems	Given the specified conditions, the occurrence of this fault could lead to potentially critical consequences. The existence of an arcing condition in the presence of flammable materials is unacceptable. In addition to the fire threat, multiple critical systems may fail. Elimination or segregation of flammable materials can mitigate the consequences of arcing.	OWNER
	6b1 Operators: Accelerate removal of flammable materials. Ensure separation of wire bundles from flammable materials. Incorporation Plan: Use of the term "flammable materials" refers to the accumulation of contaminants over time rather than an assessment of the flammability of the materials used in the construction of the airplane. Removal of materials thought to degrade the operational safety of an airplane is an appropriate response whereas removal of materials meeting a different standard from that currently in place for new airplane designs is not. Prevention of contamination, and cleaning of noted contamination on the exterior of wiring will be included in the manufacturers ESWPM. For Boeing, additional guidelines for the removal of accumulations of flammable materials are contained within the specific AMM chapter applicable to the system or zone under review. The results of the ongoing studies aimed at identifying and eliminating the use of flammable materials in the flight deck and E/E bay areas, will determine if any further OEM action is required. OEMs support the prompt removal of flammable contaminants provide effective procedures for doing so. However, they do not support the identification and removal of materials, which meet flammability requirements and do not degrade the operational safety of the airplane.	OEMs
Situation	**Recommendations**	

6c. Contamination, cockpit or electronics bay	Given the specified conditions, the occurrence of this fault could lead to potentially critical consequences. The existence of an arcing condition in the presence of flammable contaminants is unacceptable. The cockpit and electronics bay warrant special attention. Exposure of wire to fluid contaminants (e.g. water waste, hydraulic) and solid debris (e.g. drill shavings, foreign objects) must be minimized. Susceptible wire bundles should be kept free of flammable dust and lint build-up.	OWNER
	6c1 Aircraft Manufacturers: Consider design modification to minimize potential for contamination. Incorporation Plan: OEMs - Potential sources of contamination of airplane wiring are identified by OEMs during the design and development of the airplane, and appropriate protection in the form of drip or heat shields are included to minimize the effects of contamination. When unanticipated sources of contamination are identified during service operation, additional protection is specified and available to operators through a service letter or service bulletin. In the case of general protection of wiring during unrelated maintenance, OEMs will provide protection guidelines in future revisions to their ESWPM. Boeing is presently evaluating several methods of maintenance protection in various areas of an airplane. These recommendations must be validated with operators and repair stations before they are implemented into the SWPM. At this time a definitive schedule is not available. The Airbus ESPM currently provides guidelines for the cleaning of EWIS components (Chapter 20-55-00) and protection (Chapter 20-54-00) during maintenance. Any HWG7 and HWG9 recommendations will be analyzed and included if appropriate. In addition, based upon the ATSRAC and FAA recommendations that we do so, the OEMs are presently implementing notes into all service bulletins cautioning operators about the importance of protecting wiring during maintenance. Boeing implemented service bulletins incorporating this note in mid-2002. Airbus has launched corresponding actions to implement the EAPAS recommendation to include information in service data on minimizing wiring contamination during maintenance. A dedicated procedure is presently under preparation for introduction in the next available revision of the ESPM. This task will cover the recommendations and information included in ATA Specification 117. We are investigating also	OEMs

	the possibility to introduce this Task in the AMM. As soon as this specific Task will be available, a cross-reference to the ESPM or AMM will be made in all relevant Service Bulletins. Lockheed has been adding notes to its SB's recommending the utilization ATA Specification 117 guidelines when performing maintenance in, on or around wiring. All L-1011 operators have been supplied a copy of the specification and are urged to implement it into their maintenance programs. The revision of the LMCO SWPM will provide reference to ATA Specification 117. Additionally, review of our Maintenance Manuals shows that more notes should be added, regarding proper techniques and the use of suggested references. HWG6 has drafted new rules on fluid contamination (25.1703, 25.1709), and corresponding advisory material in the new AC/ACJ for EWIS. See HWG6 Final Report, Appendices A, B and D.	
	6c2 Operators: Use additional precautions when performing maintenance in the cockpit and electronics bay. Incorporation Plan: HW8 - Precautions when performing maintenance in cockpit and electronics bay is covered in Inspection Module C3; Zonal Areas of Inspection and Housekeeping Module D2 & 3; Airplane Internal Contamination Sources, and Other Contamination Sources. HW9 - This concern is addressed in Task Group 3 Report with recommendations that OEM's strengthen language in their Maintenance Documents under Specific precautions regarding protection of wiring from contaminates and damage.	Task 8/9
Situation	**Recommendations**	
6d. Contamination, multiple critical systems	Given the specified conditions, the occurrence of this fault could lead to potentially critical consequences. The existence of an arcing condition in the presence of flammable contaminants is unacceptable. Exposure of wire to fluid	OWNER

contaminants (e.g. water waste, hydraulic) and solid debris (e.g. drill shavings, foreign objects) must be minimized. Susceptible wire bundles should be kept free of flammable dust and lint build-up.

6d1 Aircraft Manufacturers: Consider design modification to minimize potential for contamination. Incorporation Plan: OEMs - Potential sources of contamination of airplane wiring are identified by OEMs during the design and development of the airplane, and appropriate protection in the form of drip or heat shields are included to minimize the effects of contamination. When unanticipated sources of contamination are identified during service operation, additional protection is specified and available to operators through a service letter or service bulletin. In the case of general protection of wiring during unrelated maintenance, OEMs will provide protection guidelines in future revisions to their ESWPM. Boeing is presently evaluating several methods of maintenance protection in various areas of an airplane. These recommendations must be validated with operators and repair stations before they are implemented into the SWPM. At this time a definitive schedule is not available. The Airbus ESPM currently provides guidelines for the cleaning of EWIS components (Chapter 20-55-00) and protection (Chapter 20-54-00) during maintenance. Any HWG7 and HWG9 recommendations will be analyzed and included if appropriate. In addition, based upon the ATSRAC and FAA recommendations that we do so, the OEMs are presently implementing notes into all service bulletins cautioning operators about the importance of protecting wiring during maintenance. Boeing implemented service bulletins incorporating this note in mid-2002. Airbus has launched corresponding actions to implement the EAPAS recommendation to include information in service data on minimizing wiring contamination during maintenance. A dedicated procedure is presently under preparation for introduction in the next available revision of the ESPM. This task will cover the recommendations and information included in ATA Specification 117. We are investigating also the possibility to introduce this Task in the AMM. As soon as this specific Task will be available, a cross-reference to the ESPM or AMM will be made in all relevant Service Bulletins.	OEMs

	Lockheed has been adding notes to its SB's recommending the utilization ATA Specification 117 guidelines when performing maintenance in, on or around wiring. All L-1011 operators have been supplied a copy of the specification and are urged to implement it into their maintenance programs. The revision of the LMCO SWPM will provide reference to ATA Specification 117. Additionally, review of our Maintenance Manuals shows that more notes should be added, regarding proper techniques and the use of suggested references.	
	6d2 Operators: Use additional precautions when performing maintenance in the vicinity of wire bundles supporting multiple flight-critical systems. Incorporation Plan Summary: HWG8 - Identification of flight critical systems is assigned to HWG 6. They are working to finalize this process. When this process is identified, it will be included in HWG 8 Curriculum and Lesson. HWG6 Follow on Comment - HWG6 has drafted a new rule on this subject (25.1711), and corresponding advisory material in the new AC/ACJ for EWIS. See HWG6 Final Report, Appendices A, B, and D. Identification of flight critical systems is covered in this material. This information has been given to HWG8.	Task 8
Situation	**Recommendations**	
6e. Multiple critical systems, arc-tracking potential	Given the specified conditions, the occurrence of this fault could lead to potentially critical consequences. Though this scenario does not assume the presence of flammable materials or contaminants, arc tracking on a bundle with multiple critical system wires can result in multiple flight-critical system failures. Separation of critical wiring into physically separate and smaller bundles can reduce the possibility of cascading failure.	OWNER
	6e1 Task Group 4: Specify enhanced separation requirements for wires with known arc-tracking potential. Specify enhanced routing requirements for wires with known arc-tracking potential that prohibit or minimize hazardous conditions such as chafing, or damage from regular activities in/about the aircraft. Incorporation Plan: HWG6 - Has drafted a new rule on this subject (25.1703, 25.1705, 25.1709, and 25.1719) and corresponding advisory material in the new AC/ACJ for EWIS. See HWG6 Final	Task 6

	Report, Appendices A, B, and D.	
General Recommendation		
There are many ATSRAC supported activities that will result in great improvement to the inspection and maintenance of aircraft electrical systems. The recommendations stemming from these activities are extremely important. The following general recommendation is meant to supplement those other recommendations. This recommendation should be considered in conjunction with those recommendations without any presumption regarding priority or importance:		OWNER
	GR1. Inspection and maintenance personnel should be made aware of the characteristic degenerative failure modes for specific wire types. Furthermore these personnel should be made aware of the types of wire they are likely to encounter on the aircraft they maintain. Task Group 5 should implement this recommendation by including appropriate material in their proposed training curricula. Incorporation Plan: HWG8 - Failure modes for specific wire types are covered in Wire Module, E2 Insulation Qualities, E3 Inspection Criteria and Standards of Wire and Wire Bundles and E5, Typical Damage and Areas Found (airplane specific). Airplane model wire types found on the airplanes that the technician maintains, are covered in Wire Module E1, Identification, Type and Construction.	Task 8
Research Recommendations of the Intrusive Inspection Working Group		
The intrusive inspection project is only a first look at state of wire in aged aircraft. As with most investigative studies of this nature, it answered some questions, failed to fully answer other questions, and raised still more questions. Cognizant of the results of this project, the working group makes the following recommendations for further research:		FAA OWNER
	GR2 The FAA should fully support its commitment to its wire degradation assessment project to begin this year. With reference to this report, the degradation assessment project should attempt to explain observed or suspected – but yet unanalyzed – phenomena on the dominant aged wire types. This research should focus on characteristic failure modes and the factors that aggravate or retard degradation. The goal of such research should be a methodology that allows us to predict with a high degree of certainty the fitness for	AAR-433

	service of wire subject to a known service environment. Incorporation Plan: A contract to complete Phase II (Testing) and Phase III (Analysis of Test Results) has been awarded to Raytheon Technical Services Company (RTSC). RTSC, Brookhaven National Labs, Sandia National Labs, and Lectromech, will conduct extensive wire testing in support of this project.	
	GR3 As part of the degradation assessment project the FAA should analyze the effects of wire-to-wire chaffing. Wires are currently selected by the aircraft manufacturer based on their specific application and their proximity to other wires in a bundle. Maintenance and subsequent modifications may result in the mixing of wire types not anticipated during original design. There is lingering concern that wires with different insulations can damage each other if bundled together. Building upon the work of the Navy Avionics Center report TR 2333 and Airbus investigations into this issue, this suspicion should be re-examined. Incorporation Plan: The FAA has three research projects that will provide data related to the assessment of this problem. The first is the wire degradation program described in item GR2. Second is the analysis and development of minimum performance requirements for aircraft wire. These two projects are underway. The third project is scheduled to begin in December 2002, and most specific to GR3 is the evaluation of the use of the application of mixed wire types in the EWIS system.	AAR-433
.	GR4 Also as part of the degradation assessment project the FAA should analyze the effects of common contaminants on wire. Special attention should be paid to corrosion control compounds. This follow-on effort should be fully consistent with and build upon the work presented in the Intrusive Inspection Working Group Report. In particular, the analysis of wire bundles taken from retired aircraft is an essential part of any such effort. The FAA should consider pursuing further laboratory testing per the intrusive inspection protocol on the currently available specimens. This would include:	AAR-433

	o Perform additional laboratory visual analysis of 747-, L1011-, and A300- specimens. o Perform additional laboratory tests based on original intrusive inspection laboratory test protocol. o Investigation of the effects of lavatory fluid contamination of PVC insulation. Also investigate other fluids/chemicals used in aircrafts. o Determine probable cause of the observed degenerative conditions (e.g. internal or external heating, fluid contamination, aging). o For PVC/Glass/Nylon, correlate the specific symptoms of aging with the mechanical and electrical properties of the insulation. Incorporation Plan: This work is being conducted as part of the research project described in GR2.	
	GR5 Excessive wire heating presents the risk of electrical fire or ignition of surrounding combustible materials. High resistance inter-connections where electrical heating is sufficient to damage the wire insulation are typically detected by visual inspection for embrittled, charred or missing insulation. However, the relationship of observable thermal damage to wire hot enough to hazard the aircraft is still unknown. It is recommended that the FAA conduct research to determine how best to manage this issue. Incorporation Plan: The FAA will review service data to establish scope of the problem and the necessity and/or scope of follow-on activity.	AAR-433
	GR6 The FAA should aggressively pursue and promote arc-fault circuit breaker development. Many of the recommendations of this report specify this as a potential option to eliminate or mitigate electrical hazards. Incorporation Plan: 115V/Single-phase arc fault circuit breaker (AFCB) development is complete. Prototypes developed by EATON Aerospace and Hendry Telephone Systems/Texas Instruments have been evaluated and flight-tested by the FAA and the Naval Air Systems Command (NAVAIR). As part of the effort to facilitate the use of AFCB technology, the FAA is working closely with the SAE to develop and publish an AFCB performance specification. The FAA, in partnership with NAVAIR, the Office of Naval	AAR-433

	Research, and the United States Air Force, is entered Phase II of the AFCB research program. The objectives of phase II are threefold: 1) Development of 28VDC AFCB's; 2) Development of 115V/3-phase AFCB's; and 3) Development of a miniaturized, MS3320 sized, AFCB. Phase II will be conducted by both Eaton Aerospace and the AMETEK.	
	GR7 The FAA should aggressively pursue and promote the development of nondestructive test equipment for aircraft wiring. Many of the recommendations of this report specify this as a potential option to eliminate or mitigate electrical hazards. As part of its Aging Electrical Systems Research Program, the FAA is currently conducting research on non-destructive inspection (NDI) and non-destructive test (NDT) methods for the inspection of the EWIS system. Numerous technologies are being researched and evaluated. A standard wiring test bed has been established at Sandia National Labs to aid in the development and testing of NDI/NDT equipment. All validation efforts will include (as applicable) test and evaluation of the NDI/NDT technique on power feeders. Results of the NDI/NDT program will be publicly disseminated.	AAR-433
	GR8 By their very nature connectors and terminals are designed to be serviceable, and they are physically localized. This suggests that these components should be less problematic than wires, which may stretch from one end of the aircraft to the other. On the other hand their relatively frequent handling and exposure to collateral damage, make connectors, terminals, their lead wires subject to repetitive stress and accidental damage. Furthermore, experience has shown that we cannot rule-out the possibility of a fire resulting from a defective or broken connector. Incorporation Plan: The assessment of aging circuit breaker performance has been completed. Performance assessment of other aging EWIS components will begin in 2003 pending availability of adequate funds for this effort.	AAR-433
	GR9 The intrusive inspection project did not fully consider connector issues. The military and commercial aviation community should sponsor efforts to scope the problem and establish research projects and maintenance guidelines to address the issue. Incorporation Plan:	AAR-433

	The assessment of aging circuit breaker performance has been completed. Performance assessment of other aging EWIS components will begin in 2003 pending availability of adequate funds for this effort.	
	GR10 Though wires and connectors are the most obvious component in electrical interconnect systems, there are others. The FAA should investigate the physical and functional integrity of any electrical system component whose failure could hazard the aircraft. This includes: circuit breakers, relays, switches, wire support and bundling systems (including conduit), shielding, ground blocks, etc. Incorporation Plan: The assessment of aging circuit breaker performance has been completed. Performance assessment of other aging EWIS components will begin in 2003 pending availability of adequate funds for this effort.	AAR-433
	GR11 The working group observed wires with breaches and non-environmental splices, and found reduced insulation resistance in certain wet wires. Though the working group did not document wire bundles with numerous, collocated breaches or non-environmental splices, the possibility should be considered. In the presence of moisture this situation could result in stray electrical currents affecting multiple systems. The FAA should investigate the possibility of this situation and its potential to hazard the aircraft. Incorporation Plan: This issue is or will be looked at via several avenues of the research program. Mitigation of this hazard is accomplished with the use of AFCB technology. The hazard will also be explored as part of the program to develop advanced risk assessment tools for aircraft electrical systems. 115V/Single-phase arc fault circuit breaker (AFCB) development is complete. Prototypes developed by EATON Aerospace and Hendry Telephone Systems/Texas Instruments have been evaluated and flight-tested by the FAA and the Naval Air Systems Command (NAVAIR). As part of the effort to facilitate the use of AFCB technology, the FAA is working closely with the SAE to develop and publish an AFCB performance specification. The FAA, in partnership with NAVAIR, the Office of Naval Research, and the United States Air Force, is entered Phase II of the AFCB research program. The objectives of phase II are threefold: 1) Development of 28VDC AFCB's; 2) Development of 115V/3-phase AFCB's; and 3) Development	AAR-433

of a miniaturized, MS3320 sized, AFCB. Phase II will be conducted by both Eaton Aerospace and the AMETEK.

The FAA is also pursuing research of advanced risk assessment tools for the EWIS system. In addition to researching potential risk assessment techniques, this project is also monitoring WG6 activities in this area (25.1705) and considering this in the research program.

APPENDIX A-COMMENTS ON OWNER INCORPORATION PLANS

INTRUSIVE

INSPECTION RECOMMENDATIONS ~

COMMENTS ON OWNER INCORPORATION PLANS *

* Also Includes owner remarks on comments

April 8, 2002 ~ original issue
April 19, 2002 ~ revises WG9 remarks
May 30, 2002 ~ Includes additional P2/P3 remarks from FAA meeting and revisions based on ATSRAC comments made in April meeting

OWNER

2.4 OEM

Review design and maintenance practices regarding the use heat shields. Establish on-condition criteria for the replacement of wire in heat-damaged bundles (external and internal heat). Develop and implement configuration management processes to prevent load creep that may result in circuits operating near the rated capacity and conductor heating

Boeing - Expected and actual sources of heat impinging on electrical wiring is presently taken into consideration during the design of the electrical system. Allowable wire damage criteria are presently specified in the SPWM. Boeing presently provides electrical load documents with the delivery of new airplanes and conducts electrical load analysis on in-service airplanes upon request

Airbus - Expected and actual sources of heat affecting electrical wiring is presently taken into consideration during the design of the electrical system. Allowable wire damage criteria are presently specified in the ESPM. Airbus presently provides electrical load documents (ELA) with the delivery of new airplanes. Airbus supplies the ELA in an electronic format to allow the operator to update the actual electrical load of the aircraft following post delivery modification of the aircraft

Lockheed - LMCO design practices have taken into consideration wiring in proximity to heat sources. Allowable damage to wire is specified in the SWPM. LMCO provided operators with a load analysis at delivery. It is the responsibility of the operator to update the analysis as required

[COMMENT, also applies to 2.4/2.5 and 2c2] From the various comments, I do not see an effort to include in the Task 6 report Part 25 Design guidelines that govern where heat shields/drip shields are to be installed. While definition by each OEM as to where such items are to be installed on a type certified airframe are provided through the maintenance delivery documentation, there is nothing for operators/STC agencies to use for after delivery changes to the aircraft. Of concern are the various interior changes done by many carriers that move galley and lavatories throughout the cabin. With these interior changes, location of wiring, potable water, and waste water lines are changing. I presently see no guidance coming that instructs when to use heat shields/drip shields when an electrical disconnect panel is now too close to the rerouted plumbing components

OWNER REMARKS: WG6 P1

A new rule is drafted under sub-part 251705 to protect EWIS from heat damage. Corresponding Advisory Materials is included in the new wire AC/ACJ for EWIS.

2a3 WG9 Investigate periodic, selective inspection and nondestructive testing of cockpit and EE bay wiring. Accelerate removal of flammable materials from the cockpit and electronics bay.

WG9 - EZAP requires full application of the logic in the cockpit and electronics bay regardless of whether combustible materials are likely to be present. Due to the congestion and difficult access to these zones, it is expected that a Zonal Inspection will not be assessed as adequate. The logic will identify dedicated visual inspections, which could be Detailed Inspections in specific areas that warrant closer attention. While "periodic" and "selective" visual inspections will be identified, the use of non-destructive testing is insufficiently mature to apply on a scheduled basis at this time.

PRIORITY

P1 ~ WG issue

P2 ~ OEM issue related to WG

P3 ~ OEM only, not related to WG

Initially, new NDT methods would likely be used to support trouble-shooting activities that will provide the necessary experience to allow assessment of their use in scheduled maintenance. To further mitigate the concern for wiring in cockpit and electronics bay areas, EZAP requires consideration of the presence of combustible materials in a zone, and identification of tasks to remove significant accumulations of combustible contamination. In addition, enhancements to maintenance practices are proposed that will minimize the risk of damage and contamination to wiring caused by maintenance activity.

[COMMENT 1] My personal belief about combustible material is that the EZAP logic should *allow* for their consideration without requiring a definitive list of combustibles. Operators would be able to implement the logic without any knowledge of the flammability properties of the material in the zone. Operators who do not confirm the absence of combustibles should assume the presence of combustibles and inspect accordingly. If, however, the operator could verify the absence of combustible materials in a zone, that operator could take credit for this by performing a less intensive inspection than would be required otherwise.
Furthermore, the classification of a zone as either containing combustibles or not can be simplified without serious detriment to safety. For example, the process could be as simple as this:

1) Consider all items in accessible zones (exclusive of the cockpit) to be non-combustible.

2) For solid materials, if the type certificate is post 1972 then the materials should pass the 60-degree burn test. Consider only AD'd materials as combustible (i.e. aluminized Mylar, not all of which will be removed from aircraft).

3) If the aircraft type certificate is pre 1972 then consider solid materials in an inaccessible zone to be non-combustible if:

a) They are metallic, or

b) They are not present in significant quantities, or

c) They are shown by subsequent analysis to pass the 60-degree burn test.

4) Fluids (hydraulic fluid, fuel, lubricants, corrosion control compounds) would be considered separately.

Item 3.c, verification of compliance with the current standards, will often be verifiable by citing continued use of the material on post-1972-type-certificated aircraft.

[COMMENT 2,also appears throughout report in 4.c.2, 4.f.1, 4.f.2, 5.a.2, 6.a.1, and 6.a.2]

Operators, Airframe Manufacturers, and FAA use an ATA developed Airworthiness Concerns Coordination process to implement corrective actions associated with unacceptable airworthiness risks to the operational fleets. As we have discussed in past ATSRAC meetings, it is going to be impossible for all parties to agree as to what exactly defines a material as an unacceptable flammable material. Any party may initiate an airworthiness concern item to be handled via the ACC process. I would propose that all desired flammable material removal from any of the operational fleets use this process. As an example, the metalized mylar insulation used this process and resulted in an AD to remove the blankets in most areas of the aircraft over a 5 year period. Each flammable material of concern should use the same process

OWNER REMARKS: WG9 P1

While there is no specific restriction that prevents consideration of the presence of flammable material types when accomplishing the EZAP should an operator choose to

do so, EZAP was not designed or intended to identify tasks to mitigate the risk posed by the presence of such materials. The FAA took ownership of this question at the January, 2002, ATSRAC meeting and in March, 2002, published it's position that ATSRAC tasking did not include consideration of the flammability characteristics of uncontaminated materials, nor was ATSRAC tasked to address the "gap" that is perceived to exist between current certification standards vs. those used to certify earlier designs. The FAA essentially concluded that the material flammability issue will be best addressed by the outcome of R&D and other efforts currently underway within FAA. T9WG maintains that use of EZAP to address flammability characteristics of uncontaminated materials will require the development of an industry agreed upon list of materials that do not meet current standards. In regard to pre-vs-post 1972 certification as a means to exclude certain designs or materials from consideration, this does not address the certainty of post-1972 modification via STC (or other means) where FAA surveillance and enforcement of standards may have been less stringent that on the original aircraft manufacturer.

2e2 WG6/7

Ensure that wiring separation and segregation guidelines that consider loss of multiple critical functions from a common mode failure are specified.

WG6 - Task Group 6 has reviewed and discussed this item in the last Seattle meeting. A FAR requirement similar to JAR 25.1353 (d) is being considered to be included in the wiring FAR section.

[COMMENT] Please state what this is.

OWNER REMARKS: WG6 P1

A new rule is drafted under sub-part 251705 so that under normal or failure conditions as defined by 25.1309, it will not adversely affect the simultaneous operation of any other system necessary for combined safe flight, landing and egress. Corresponding Advisory Materials is included in the new wire AC/ACJ for EWIS

2e2

WG7 - Wiring separation and segregation requirements will be required as SWPM/ESPM minimum content.

[COMMENT] And are generally inadequate. Need to prevent the SWR 111 (MD-11) wiring scenario from happening again.

OWNER REMARKS: WG7 P1

This comment refers to the HWG7 response to the recommendation that wire separation and segregation guidelines that consider the loss of multiple critical functions from a common failure be included as minimum content in the OEM standard wiring practices manual. While this information is considered to be minimum content HWG7 suspects that the comment relates to the adequacy of these guidelines in light of recommendations emanating from the TSB.

Wire separation guidelines outlined within the OEM standard wiring practices manuals reflect those used during and certified for airplane manufacture.

2f1 WG6

Ensure that wiring separation and segregation guidelines that consider loss of multiple critical functions from a common mode failure are specified.

WG6 - Task Group 6 has reviewed and discussed this item in the last team meeting. A FAR requirement for general wiring separation is being considered for inclusion in the new Wiring FAR section. In addition, new Advisory Materials will also be developed.

[COMMENT] How general? See earlier comments also.
MJN - I'm assuming comments referred to are ". Need to prevent the SWR 111 (MD-11) wiring scenario from happening again.."

OWNER REMARKS: WG6 P1

A new rule is drafted under sub-part 251705 so that under normal or failure conditions as defined by 25.1309, it will not adversely affect the simultaneous operation of any other system necessary for combined safe flight, landing and egress.
Corresponding Advisory Materials is included in the new wire AC/ACJ for EWIS

3a FAA

Given the specified conditions, the occurrence of this fault could lead to potentially critical consequences. Wire or wire bundle chafing in the presence of flammable materials in the cockpit or electronics bay could result in wire-to-structure or wire-to-wire shorting arcing resulting in fire. Flammable contaminants increase the potential for ignition. More emphasis on cleaning and prevention of fluid contamination (e.g. drip shields) can mitigate the risks presented by contaminants and aid in the detection of chafing conditions. Nondestructive testing can detect wire chafing (after significant dielectric breakdown) and aid in repair.

[COMMENT] Original statement says flammable materials or contamination? Clarification from commenter - The answer to the question only deals with contamination as I read it. That is the only action mentioned. Flammable materials, per our discussions in
Committee appears to be ignored.

MJN – since this comment (a) appears to relate to all the items in 3a , and due to the fact that the FAA are developing a position on this subject, I have assigned it to the FAA for comment.

OWNER REMARKS: FAA P1

MJN - Subsequent to these comments being received the FAA has published their position on flammability and was distributed to all ATSRAC members by the ATSRAC Chair on March 25, 2002. The relevant section is quoted below:
"…In summary the FAA does not require that ATSRAC address the flammability of material adjacent to wire systems. The data collected by ATSRAC, and the subsequent recommendations addressed failures of wire systems and not the flammability of material adjacent to wire systems. Efforts are underway that will reduce the presence of material that does not meet current flammability standards. Establishing logic in the EZAP to address flammability is not straightforward and would not consider all possible sources of ignition. ATSRAC and EAPAS efforts will significantly reduce the probability of ignition sources. Given the above, and considering the current difficulties with meeting existing tasking schedules, the FAA recommends that ATSRAC focus their recommendations on minimization of ignition sources.

If ATSRAC determines that the EZAP logic should address flammability of materials in a zone it is suggested that they make a request to the FAA for new tasking to consider using the EZAP to address flammable materials adjacent to wiring. As the flammability aspect is outside of the current tasking and the HWGs were not established with the appropriate specialists it would be unreasonable to address it at this point. The FAA will continue to address the usage of materials that exhibit unsafe flammability characteristics under current processes…"

3a1	WG6/7	(a) Develop situation-specific guidance to ensure the proper attention to protection and cleaning wire bundles. (b) Develop guidance on the separation of wire bundles from non-fire-retardant materials WG6 - New Regulatory as well as Advisory materials for wiring separation are being developed by the group for inclusion in appropriate sections [COMMENT] Progress? Clarification - I was simply worried about the progress of the group. I think this item is now closed for me as I have heard of the progress they have made at their recent meeting. OWNER REMARKS: WG6 P1 A new rule is drafted under sub-part 251705 to ensure that appropriate separation of EWIS components exist from other susceptible materials. Corresponding Advisory Materials is included in the new wire AC/ACJ for EWIS WG7 - General and conditional wiring protection and cleaning procedures will be included in the SWPM/ESPM minimum content [COMMENT, also applies to 3a2] While we have struggled to get ATA/operator participation to the Task 7 working group, I am concerned cleaning practices may be developed independent of the end user. Cleaning specifications need to have a thorough review and trial application with both OEM maintainability engineers and operator engineering staff. We need to assess both the advantages of a clean wire and the risks associated with damage from cleaning methods. I would ask Task 7 WG advise how they would validate cleaning practices they intend to put into the SWPM and I could work on operator participation in this phase of Task 7's effort OWNER REMARKS: WG7 P1 HWG7 was tasked with defining the minimum content to be contained within a standard wiring practices manual. Although wiring cleaning and protection procedures were selected by HWG7 as minimum content, developing, validating and presenting those procedures remains the responsibility of the OEM or operator. Supplemental OEM remarks-OEMs have not previously included in our standard wiring practices documents specific procedures for the cleaning and protection during maintenance of wiring for various reasons. One significant reason is that operators were expected to develop airline-specific procedures based upon their unique expertise. Because the OEMs are now incorporating recommended procedures for the cleaning and protection of wiring during maintenance it is prudent that these procedures not conflict with those developed by and in use at airlines. We are developing these procedures in conjunction with airlines to ensure that our procedures are clear, concise and do not compromise existing procedures. In addition, HWG7 recommendations will be evaluated and addressed accordingly. The Airbus ESPM currently provides guidelines for the cleaning of electrical components (Chapter 20-55-00) and protection (Chapter 20-54-00) during maintenance. Follow on remarks from the FAA Technical Center The FAA Technical Center is conducting research to evaluate the effects of aircraft maintenance on the electrical interconnect system throughout the aircraft. This evaluation includes an assessment of maintenance practices directly associated with the electrical interconnect system and those practices on other systems that may impact the

		electrical Interconnect system indirectly. This evaluation will include processes for the cleaning of wires and wire bundles.
3a2	WG7	(a) Specify situation-specific standards to ensure wire bundles are properly protected and cleaned based on OEM approved practice WG7 - (a) General and conditional wiring protection and cleaning procedures will be included in the SWPM/ESPM minimum content [COMMENT] The findings of the intrusive inspection team make it clear that compliance with existing airplane maintenance manuals for protection and cleaning of wires is neither preventive nor sufficient to insure wire integrity OWNER REMARKS: WG7 P1 HWG7 was tasked with defining the minimum content to be contained within a standard wiring practices manual. Although wiring cleaning and protection procedures were selected by HWG7 as minimum content, developing, validating and presenting those procedures remains the responsibility of the OEM or operator. Supplemental OEM Remarks- The OEMs disagree that the findings of the IIWG question the adequacy of protection and cleaning procedures provided in the airplane maintenance documentation. The stated conclusion from the IIWG report indicates that visual inspection is an effective tool for identifying some types of wire damage, but ineffective in detecting others. The IIWG did not review the procedures contained with the airline's maintenance documentation or whether those procedures had been in use on the airplane under inspection. The OEMs reviewed the results of the intrusive and non-intrusive inspections, reviewed our procedures, limitations and guidelines with those results in mind, and believe that proper use of the existing recommendations would have prevented or mitigated the effects of wiring damage. Please note that neither the OEM recommendations nor the ATA Specification 117 included procedures for the cleaning and protection of wiring during maintenance prior to either the intrusive or non-intrusive inspections. Follow on remarks from the FAA Technical Center The FAA Technical Center is conducting research to evaluate the effects of aircraft maintenance on the electrical interconnect system throughout the aircraft. This evaluation includes an assessment of maintenance practices directly associated with the electrical interconnect system and those practices on other systems that may impact the electrical Interconnect system indirectly. This evaluation will include processes for the cleaning of wires and wire bundles.
3b1	(a) WG7/8/9 (b) WG6/OEM	(a) Develop situation specific guidance to ensure the proper attention to protection and cleaning wire bundles. (b) Develop guidance on the separation of wire bundles from non-fire-retardant materials. WG9 - (a) MSG3, Rev 2001.1 EZAP logic includes a determination if accumulation of combustible material likely in a zone, and selection of task(s) to prevent significant accumulation of combustible material. [COMMENT] Or installed combustibles

OWNER REMARKS: WG9 P1

EZAP was not designed or intended to identify tasks to mitigate the risk posed by the presence of properly certified, uncontaminated materials. The FAA took ownership of this question at the January, 2002, ATSRAC meeting and in March, 2002, published it's position that ATSRAC tasking did not include consideration of the flammability characteristics of uncontaminated materials, nor was ATSRAC tasked to address the "gap" that is perceived to exist between current certification standards vs. those used to certify earlier designs. The FAA concluded that the material flammability issue will be best addressed by the outcome of R&D and other efforts currently underway within FAA. T9WG maintains that use of EZAP to address flammability characteristics of uncontaminated materials will require the development of an industry agreed upon list of materials that do not meet current standards.

Boeing - (b) Spatial separation of wiring from structure, systems components, or other wiring is accounted for in the design of the wiring system. The guidelines used to design the wiring system are contained within the Standard Wiring Practices Manual

Airbus - (b) The rules for the separation of wiring from structure, systems components, or other wiring is accounted for in the design of the wiring system. These separation guidelines are contained within the ESPM

Lockheed - (b) LMCO design specifications and the SWPM contain specific bundle category and segregation distances.

[COMMENT1] But not adequately, ref SWR111 and MD11

[COMMENT 2] Is the spatial separation of wiring in the wiring system design sufficient in the light of today's knowledge? What is the point of conducting inspections if we do not reevaluate designs using the information gleaned from those inspections? On what is the ATSRAC to base our acceptance of Boeing's claim that the wiring system design guidelines fully address what was discovered in the intrusive inspection report?

OWNER REMARKS: WG6/OEM P1

WG 6 - Boeing's wiring system separation design adequately covers most of the situations, however, it may be necessary to review certain specific situations for the separation distances from airplane structures and other components. These situations are covered by the new AC/ACJ for EWIS.

OEM - The OEMs do not understand the reference to SWR111 and MD-11, and how that relates to the spatial separation of OEM wiring systems. Additional clarification is desired (see below)

Follow on additional clarification:

(I) was referring to the fact that wiring in the MD-11 wiring was next to flammable material (metalized Mylar). The task stated above "b) Develop guidance on the separation of wire bundles from non-fire-retardant materials." There are other types of insulation, although certified, can be considered flammable. One of these is metalized Tedlar. Metalized Mylar has been addressed through AD, but other items have not. Boeing did not address this issue that I can see.

With regard to comment 2, the OEM replies to the IIWG7 recommendation addressed whether guidance needed to be developed to address separation of wiring from non-fire retardant materials. Our replies indicated that this aspect of separation was accounted for during airplane design. The IIWG report did not indicate that changes to wire separation guidelines were needed to assure wire integrity.

Please note that the OEMs reviewed the results of the intrusive and non-intrusive inspections, reviewed our procedures, limitations and guidelines with those results in mind, and believe that proper use of the existing recommendations would have prevented or mitigated the effects of wiring damage found during the inspections. The results of this review was presented and accepted by the FAA members participating in the inspections.

In addition to the above, any new requirements which may arise from HWG6 Sub-tasks 6.7 (Wire Separation Requirements), 6.6 (Wire System Safety Assessment Requirements) and 6.8 (Wiring Identification Requirements) will be analyzed and applicable documentation updated accordingly.

Follow on remarks from the FAA Technical Center

The FAA Technical Center is conducting research to evaluate the effects of aircraft maintenance on the electrical interconnect system throughout the aircraft. This evaluation includes an assessment of maintenance practices directly associated with the electrical interconnect system and those practices on other systems that may impact the electrical Interconnect system indirectly. This evaluation will include processes for the cleaning of wires and wire bundles.

3c1	WG7	(a) Specify guidelines to ensure the proper attention to protection and cleaning wire bundles

WG7 - (a) General and conditional wiring protection and cleaning procedures will be included in the SWPM/ESPM minimum content.

[COMMENT] Has there been a review of wire attachments that look specifically at the areas where the intrusive inspection discovered problems with loose or missing connections? Have these situations been incorporated into the SWPM?

OWNER REMARKS: WG7 P1

HWG7 did not conduct such a review of the OEM-specified wire attachment procedures. Wire attachment and interconnect information is considered to be minimum content for the electrical systems standard wiring practices manual.

3g1	WG9	Specify more detailed inspection and testing to ensure potential chafing problems are spotted and corrected.

WG9 - MSG3 Rev 2001.1 EZAP logic includes a detailed listing of "Details of Zone", where installed equipment, wire bundles, possible combustible materials present, L/HIRF protection features, etc., are determined as a prerequisite to conducting Zonal Analysis of a zone. Due to their high current potential and ease of identification (size), presence of feeder cables should be specifically noted in the list of details in a zone and considered for Detailed Inspection based on zone environment and frequency of maintenance access to the zone where potential damage could occur. Use of non-destructive testing is insufficiently mature to apply on a scheduled basis. Initially, new NDT methods would likely be used to support trouble-shooting activities, which will provide the necessary experience to allow assessment of their use in scheduled maintenance

[COMMENT] From the various comments in this section, the quantity of Service Actions aimed at the power feeder cables reviewed as a part of Task 2's tasking, and

NWA's experience with this system, I concur that this system warrants special review. However, I don't know that I see a system review recommendation from the Task 9 WG comments. WG9 indicates power feeder cable elements should be specifically listed when doing EZAP analysis, however I wonder if a specific review of the entire system for maintenance actions would yield a better maintenance program for this area of concern. Specifically, items such as periodic torquing of terminal lugs, functional tests of cross tie lock out systems, power transfer tests may need review. EZAP focuses on wiring system components in the zone and will address some of the concerns with this system but many of the functional checks assigned and those intervals may remain as is. Should this important system have another assessment of overall maintenance tasks done from a systems approach knowing the criticality of defects in this system?

OWNER REMARKS: WG9 P1

T3WG and T9WG were not tasked to consider or identify particular systems that may benefit from an overall review of the entire system for maintenance actions. EZAP was developed as an enhancement to existing Zonal Analysis methods in response to the need to address wiring discrepancies which are not normally considered in the loss of function analysis performed at the system level. However, T9WG agrees that power feeder wiring should be specifically identified when listing the "Details of the Zone" when accomplishing the EZAP due to its potential for high energy release as a result of accidental or environmental damage. This ensures that the analyst will consider environment and potential for accidental damage to this wiring in the task selection portion of the EZAP. Normally, tasks such as re-torque terminal lugs on particular electrical components are derived from service experience or inspection findings. EZAP should be effective in the selection of visual inspections (either GVI or DET as warranted by zone size, density, and potential impact of a localized fire) which should detect evidence of an overheat condition on high power terminals. Such a finding should cause an operator to consider additional tasking to prevent the overheat condition, such as periodic re-torque of the terminals.

4a1 WG7

Specify accelerated removal of flammable material

WG7 - General and conditional cleaning procedures will be included in the SWPM/ESPM minimum content

[COMMENT] Task Group 7 has not addressed the recommendation. Operators have several years to remove aluminized Mylar insulation materials. The recommendation was that operators prioritize, where possible, removal of this material in cockpits and electronics bays

OWNER REMARKS: WG7 P1

HWG7 was tasked with defining the minimum content and common format to be used for electrical systems standard wiring practices manuals. The recommendation that HWG7 consider the inclusion of accelerated removal of flammable materials prompted the response that cleaning procedures will be included as minimum content.

The removal of flammable, non-fire retardant or contaminated materials unrelated to wiring, such as metalized Mylar, is beyond the scope of the electrical systems standard wiring practices manuals.

4b3 WG6

Consider design modification to enhance wire separation requirements for this specific situation. Consider local design modification to replace non-fire-retardant materials

WG6 - Task Group 6 is considering development of new Advisory Materials for this item. The new AC material will be included in the revised AC for wiring

[COMMENT 1] Their idea is the present SWPM
Clarification from commenter - I can see some of the confusion here. I was referring to WG 6 and the progress so far in that group as of when I wrote the reply. It had appeared to me to be accepting that present practices were good enough and no changes
were needed. I disagreed, what was the point in doing the Intrusive Inspection if we did not make some changes based on the information we garnered. I understand there has been some movement on these issues lately. I hope they address the concerns I had earlier voiced on wire separation issues

[COMMENT 2] Although this Recommendation is aimed at aircraft manufacturers, the incorporation plan does not include an entry covering OEM responses. Also my comment against 4.a.2 applies (see below)
ATSRAC has spent a great deal of time debating the issues surrounding the treatment of flammable materials in zones, without reaching a firm conclusion on whether materials that meet the regulations extant at the time of original certification should automatically be considered adequately fire resistant. I do not want to restart that debate here, but I would like to put down a marker that ATSRAC's conclusion on that issue should determine how vigorously design modifications to replace non fire retardant materials should be pursued. That, in turn, will determine whether the responses to Recommendation 4.a.2 can be considered acceptable or not.

OWNER REMARKS: WG6 P1

WG 6 discussed the issue of non fire retardant material and separation from EWIS components. Separation of EWIS components from various airplane systems such as fuel systems, oxygen systems and others are adequately covered by the new FAR/JAR 25.1705 requirements and the new AC/ACJ for EWIS. As far as the replacing the non fire retardant material – it was determined that this item is beyond the scope of Task group 6.

6d2 WG8

Use additional precautions when performing maintenance in the vicinity of wire bundles supporting multiple flight-critical systems

WG8 - Because of the difficulty of identifying flight critical wire bundles, all wire bundles are to be treated identically. ESPM data will be used at all times as covered in Wiring Practices Documentation Module B and Wire Module E3, 4 & 6; Inspection Criteria and Standards of Wire and Wire Bundles, Wire Bundle Installation Practices, and Maintenance and Repair Procedures

[COMMENT] Task 8 WG comments that it must treat all wire bundles identically since there currently is difficulty in identifying flight critical wire bundles. I was expecting to find some mention here that in the future an identification standard would be phased in on new aircraft that will make this task easier for operators maintaining wiring systems of newer generation aircraft. Does WG 6 have this task and has it made a determination of whether it will have requirements to specifically identify flight critical system wiring differently for future operators maintenance programs. If so, could comments be added to this section of the Intrusive Recommendations report? As it shows now, it leaves me with the impression that I will always have to inspect every bundle on the aircraft the same, when I believe the recommendation's intent is for more scrutiny to be applied against flight critical wiring. We need to move to help in identifying these wire systems on future aircraft.

OWNER REMARKS: WG8 P1

Identification of flight critical systems is assigned to WG 6. They are working to finalize this process. When this process is identified, it will be included in WG 8 Curriculum and Lesson

PRIORITY 2 ITEMS

PRIORITY

P1 ~ WG issue

P2 ~ OEM issue related to WG

1.1 WG 7/0EM

Update splicing practices as necessary. Consider procedure to tag locations of splices to aid in future visual inspection

Boeing - Boeing has reviewed our present splicing practices in light of the results of the intrusive inspection and believe that no changes are necessary at this time

Airbus - All production splices are covered in the Airbus standard documentation. While the ESPM stipulates the maximum permitted number of splices per wire. Airbus will include in ESPM guidelines to inform operators of the need to tag locations of splices

Lockheed: Per the original design, production splices are addressed in the WDM's and are physically marked on the aircraft wire bundles

[COMMENT 1] This recommendation arose from the finding, albeit infrequently, of degraded splice repairs. The original recommendation anticipated the need for updated splicing practices and procedures as a means to reduce the instances of degraded splices in the fleet. The only OEM response received up to now has concluded that no changes to their splicing practices are necessary. That response raises the further question of what is now different? Have the splicing practices changed at some point in the past in a way that will decrease the occurrence of degraded splices in the future? Alternatively, if the written practices have not changed significantly, and the practices themselves are deemed to be adequate, is there something in the implementation that needs to be addressed in order to reduce the instances of degraded splices in the fleet? I think ATSRAC needs to be assured that measures are in place to control the potential for further degraded splices before it can close off this item permanently

[COMMENT 4] Supplemental Comment – "Boeing has reviewed our present splicing practices in light of the results of the intrusive inspection and believe that no changes are necessary at this time."

SWPM 20-30-12 states

A sealed splice is necessary if on these conditions are applicable:

The temperature grade is B or higher

The splice is in an un-pressurized area

The splice is in a circuit with an operating voltage that is greater than 115 volts."

A closed end splice is necessary if these two conditions are applicable:

The splice is in a pressurized area

The splice is in a circuit with low system voltage.

Though it is not stated explicitly in the manual, I assume that the necessity of the "closed end splice" is to preclude the use of an "unsealed butt splice. Presumably a sealed splice would be an acceptable, even preferable, alternative to the closed end splice.

One potential improvement to 20-13-12 consistent with the recommendations of the Intrusive Inspection Working Group would be to require sealed splices for all repairs and modifications to aircraft electrical wire systems. On page 44 of 20-30-12 a note indicates that "a sealed, closed end splice is recommended 1) to replace a damaged closed end splice and 2) when it is necessary to install a new closed end splice. Though adherence to this practice would ensure that every new splice on an aircraft is sealed, it should be strengthened (required instead of recommended) and put on page 4 with other general information.

If this enhancement is impractical, sealed splices could be required for a broader variety of condition than those mentioned on page 4. Other conditions added to the list of conditions requiring sealed splice would include moisture-prone areas and locations under lavatories and galleys and cockpit and electronics compartment wiring.

Though 20-10-11 identifies the need to correctly mark replacement wire, there is no requirement or even recommendation to mark and record splices. The absence of this practice makes requirement that there be no more than three splices in any wire difficult to implement.

OWNER REMARKS: OEM P2

The supplemental comments provided by the OEMs indicated that, based on the information provided in the IIWG report coupled with the results of the non-intrusive inspection, review of the recommended splicing practices indicated that no changes to the present splicing have been identified. The OEMs firmly believe that the proper use of our standard wiring processes and procedures will result in a permanent installation that will not degrade over time.

Tagging or physical identification of the splice location is not presently a recommended practice. Due to the nature of the splice installation practices, a repair splice is usually placed on the outside of the wire bundle where it is visible for conditional inspection. The system in which the wire applies may be determined by verifying the wire number, and the system to which the wire applies can be verified by consulting the Wiring Diagram Manual. Some OEMs specify the system directly on the wiring.

However, Task 6 is expected to provide inputs to the FAA regarding the use of non-environmental splices. The OEMs will consider any future recommendation accordingly.

In addition to the above, Airbus will include in the ESPM guidelines to inform operators of the need to tag and record locations of repair splices. Boeing prefers to give operators the option of determining the best methods to assess the number of splices present within a wiring run.

1.5b WG6/OEM (b) Develop wiring configuration management software that will track the installation and location of splices. (c) Develop best practices regarding the maximum number of splices permitted for various types of circuits based upon frequency and severity of potential splice failures

Boeing - (b) Boeing has no plans to develop configuration software to track the location of splices on in-service airplanes

Airbus - (b) Airbus recommends that operators maintain a record of the location and installation of repair splices

Lockheed - (b) LMCO has no plans to develop wiring management software

[COMMENT 1] The “best practices” the Working Group had in mind would be developed with respect to the frequency and severity of splice failures. These considerations are not the same as system reliability concerns.

[COMMENT 2] The only OEM response received up to now shows the item to be CLOSED and GREEN, yet the actual response itself was a direct refusal to adopt the recommendation. I cannot recall ATSRAC debating specifically the merits of developing wiring configuration management software to track the installation and location of splices. However, in the light of this rejection ATSRAC will need to

decide how important we feel this recommendation was, and whether we are content that no action is to be taken.

[COMMENT 3] If Boeing has no plans to develop software to track the location of splices on airplanes, what method is used to track splices? Are there any location limitations for wire splices? Are there any limitations on splicing specific to the type, load or function of the wire? What is the maximum number of splices Boeing finds permissible? On what data is this figure based?

OWNER REMARKS: OEM P2

Development by the OEMs of software to record the location of repair splices on in-service airplanes was determined to be an inappropriate recommendation. Should a tracking procedure be deemed beneficial the method of identifying, recording, or tracking repair splices on in-service airplanes should be assessed by the individual operator based upon their knowledge and expertise.

The OEMs account for production splices and indicate the location of these splices within the Wiring Diagram Manual. Manufacturing repair splices are accounted for in the disposition of production rejection or repair tags which are provided to the operator prior to airplane delivery. Repair splices made by the operator or mod center could be annotated on the wiring diagram I the same manner.

The answers to questions regarding location, type, load, or limitations on the frequency of use are unique to the OEM. This information can be obtained by referring to the individual standard wiring practices manual for that OEM.

Please note that the guidelines provided to operators regarding the number, location, type or frequency of splices do not comprise limitations, nor does exceeding these guidelines pose a safety concern. Due to the need for additional slack within a wire bundle when installing a splice, rarely are multiple splices installed on the same wire between connectors. The vast number of multiple repairs are addressed by replacing the damaged wire or adding a supplemental wire to the bundle rather than using multiple splices. Due to this practice documenting the location of repair splices within a software program would be more onerous than beneficial.

1a1 OEM

Consider updating splicing practice to reflect special considerations associated with 1) the proximity of the splice to non-fire-retardant materials and 2) the expected wire current.

Boeing - Boeing has no plans to specify different splicing practices to accommodate adjacent materials or circuit loads

Airbus - Task Group 6 reviewed the item in November task group meeting and agreed to consider updating the splicing section of the current advisory materials. Revised material is expected to be provided to ATSRAC by July 2002

Lockheed - LMCO has no plans to deviate from its current splicing practices outlined in the SWPM in order to address adjacent materials or current loads

[COMMENT 1] As stated in the preamble to the specific recommendations, each recommendation represented an option, but not the only option, for remedying a condition. If Boeing feels that this remedy is impractical, then that is an argument for requiring environmental splices for all applications and areas

[COMMENT 2] I wanted to be sure I understood the comments listed here as they also appear at various other locations in the document. Boeing has commented they have

no plans to specify such special considerations, yet Task 6 agreed to do it and include in their July report. I have assumed these comments reflect historical comments and that the Task 6 agreement to include in their report postdates the Boeing comment. If there were a disagreement here, I would be interested in hearing this at future Task 6 report.

[COMMENT 3] The only OEM response received up to now shows the item to be CLOSED and GREEN, yet the actual response itself confirms there are no plans to specify different splicing practices to accommodate adjacent materials or circuit loads. I note that Task Group 6 have agreed to consider updating the splicing section of the current advisory materials, with the revised material expected to be provided to ATSRAC by July 2002. I propose that once this material is available ATSRAC should reconsider the response(s) to Recommendations 1.a.1 & 1.b.1, to determine whether we are content that no action is to be taken.

OWNER REMARKS: OEM P2

As indicated in the Boeing reply, splices are specified in the wiring design based upon the wire size, a direct result of the load on the circuit. As the fire-retardancy properties of adjacent materials is not normally known during the design or repair of the electrical system, this recommendation is impractical. Typically the most restrictive condition, such as the presence of fuel vapor, is used to assess the splice type and installation technique, rather than assess the type and proximity of all adjacent materials within a wiring run.

To address special conditions the use of only environmental splices is one option, the replacement of non-fire retardant or flammable materials another, and the proper use and installation of appropriate splices to reduce the potential of high-resistance heating of the splice a third. The OEMs will consider any forthcoming recommendations regarding improvements in splicing practices to prevent the potential for high resistance heating in the presence of flammable materials.

In addition, Airbus uses only environmental splices in production and only environmental splices are allowed for repair.

1b1 WG/6OEM

Consider updating splicing practice to reflect special consideration associated with high-current carrying splices in bundles with wire supporting multiple flight-critical systems

Boeing - Boeing has no plans to specify different splicing practices to accommodate adjacent materials or circuit loads

Airbus - Airbus will await any forthcoming revision to the splicing section of the current AC as recommended by HWG6. Airbus includes in the ESPM splicing practices. These rules take into consideration the function ant use pertaining to that wire

Lockheed - LMCO has no plans to update splicing practices with special consideration for high current splices. The SWPM provides the correct method for making high current splices. Flight critical systems are segregated from high current systems

[COMMENT] The only OEM response received up to now shows the item to be CLOSED and GREEN, yet the actual response itself confirms there are no plans to specify different splicing practices to accommodate adjacent materials or circuit loads. I note that Task Group 6 have agreed to consider updating the splicing section of the current advisory materials, with the revised material expected to be provided to ATSRAC by July 2002. I propose that once this material is available ATSRAC should

reconsider the response(s) to Recommendations 1.a.1 & 1.b.1, to determine whether we are content that no action is to be taken.

OWNER REMARKS: OEM P2

As indicated in the Boeing reply, splices are specified in production based upon the wire size, a direct result of the load on the circuit. The OEM ESWPM typically provides special procedures for routing and splicing of power feeder cables. However, noting the expected actions of HWG6, the OEMs will consider any forthcoming recommendations regarding improvements in splicing practices related to high-current applications adjacent to or within wire bundles containing flight-critical systems.

In addition, Airbus uses only environmental splices in production and only environmental splices are allowed for repair.

As already mentioned in the owner remarks to recommendation 1.3,
Airbus does not allow feeder repair above certain gauges, depending of the nature of the conductor (copper or aluminum). This is fully explained in the ESPM Chapter 20-53-25. Boeing provides power feeder repair information within SWPM 20-10-13 and power feeder splice procedures within SWPM 20-30-12.

2c1 WG9/OEM Insure that drip guard installation and maintenance are appropriately specified

WG9 - Installation of drip shields is an OEM design issue, and existing Zonal Inspection requirements should be adequate to detect malfunction, degradation, or failure of a drip shield. However, it is possible that a drip shield could inadvertently be left off after performing maintenance in a zone and the missing shield would not necessarily be clearly evident. While this situation could exist on any aircraft, HWG9 concludes that older aircraft that have undergone repetitive heavy maintenance events are more likely to have experienced such an event. HWG9 recommends that aircraft manufacturers provide guidance to Operators for all such drip shields required on each aircraft model. If inspection for the shields reveals inadvertent removal has occurred, consideration should be given to enhancement of maintenance documents (task cards, manuals, etc.) with additional information to ensure compliance with drip shield installation requirements

[COMMENT] Under the Incorporation Plan, HWG9 has recommended that aircraft manufacturers provide guidance to Operators for all such drip shields required on each aircraft model. For completeness, this transfers an action to the OEMs that needs to be covered by a supplemental OEM comment, as it is in 2.d.2.

OWNER REMARKS: OEM P2

As with any component installed on the airplane, except as cited within the Configuration Deviation List contained within the Dispatch Deviations Procedures Guide, wiring protection shielding and guards are required to be installed on the airplane during revenue service. Replacement of removed shields and guards is both a standard practice and a regulatory requirement. It is the responsibility of each operator to ensure that the design integrity of the airframe is properly maintained and to incorporate maintenance and inspection programs that follow industry best maintenance practices.

The OEM's believe that, although there exists the possibility that some protection may have been inadvertently omitted on airlines undergoing extensive modification, we believe that the existing maintenance procedures in place at the airlines would dictate that such omissions would be rare. We also believe that the effects of such an

omission would be minor in scope but still recognizable through normal or enhanced maintenance activities.

Operators should use the guidance provided in the forthcoming wiring inspection programs, coupled with the guidance contained within the OEM standard wiring practices documents to either identify damage caused from missing drip or heat shields, or identify the conditions that would necessitate protection. The OEMs believe that any wiring systems training program should emphasize the purpose and necessity of wiring protection systems.

FOLLOW UP OWNER REMARKS: WG9

WG9 concurs that there is insufficient evidence of problems related to missing drip or heat shields to warrant a fleet wide campaign to check for drip shield installation. Determination of type and number of drip shields per individual aircraft configuration and post delivery modification would be complex and considered unjustified.

2d2	OEM/WG9	Ensure that drip guard installation and maintenance are appropriately specified

WG9 - Installation of drip shields are an OEM design issue, and existing Zonal Inspection requirements should be adequate to detect malfunction, degradation, or failure of a drip shield. However, it is possible that a drip shield could inadvertently be left off after performing maintenance in a zone and the missing shield would not necessarily be clearly evident. While this situation could exist on any aircraft, HWG9 concludes that older aircraft that have undergone repetitive heavy maintenance events are more likely to have experienced such an event. T9HWG recommends that aircraft manufacturers provide guidance to Operators for all such drip shields required on each aircraft model. If inspection for the shields reveals inadvertent removal has occurred, consideration should be given to enhancement of maintenance documents (task cards, manuals, etc.) with additional information to ensure compliance with drip shield installation requirements.

Airbus - Potential source of contamination of airplane wiring are identified during the design and development of the airplane, and appropriate protection in from of drip or heat shields are included to minimize the effects of contamination. If in-service experience shows that additional protection against contamination is required, then a design modification will be developed to provide additional protection. This will be made available to operators through a service bulletin. In the case of general protection of wiring during unrelated maintenance, Airbus will be providing protection guidelines in an upcoming revision to the ESPM

[COMMENT 1] Are visual inspections sufficient to give a complete picture of whether moisture is or has been present in wiring? The intrusive inspections showed that visual inspections do not work to discern the majority of wiring flaws.

With this is mind it seems negligent and wrong to take the position that visual inspection is the “preferred NDT inspection method” knowing that it does not work to discern the majority of wiring flaws including and especially detecting flaws, nicks and cuts within a wire bundle or under clamps, loss of continuity problems, and sometimes does not reveal heat or arcing damage in wire insulation.

Though detailed visual inspections are an improvement, there are many testing procedures and devices available today that go beyond that. There should be no further delay in evaluating and incorporating proven NDTs in wire inspection and maintenance programs

Furthermore, ALPA raises the issue that not all aircraft in need have drip shields. Is this a manufacturer issue or an operator issue? Does the OEM agree with this assessment?

[COMMENT 2] From the various comments, I do not see an effort to include in the Task 6 report Part 25 Design guidelines that govern where heat shields/drip shields are to be installed. While definition by each OEM as to where such items are to be installed on a type certified airframe are provided through the maintenance delivery documentation, there is nothing for operators/STC agencies to use for after delivery changes to the aircraft. Of concern are the various interior changes done by many carriers that move galley and lavatories throughout the cabin. With these interior changes, location of wiring, potable water, and waste water lines are changing. I presently see no guidance coming that instructs when to use heat shields/drip shields when an electrical disconnect panel is now too close to the rerouted plumbing components.

OWNER REMARKS: OEM P2

The use of general and detailed visual inspections of wiring installed in airplanes remains the preferred method of detecting actual or the potential for damage to wiring. This preference accounts for the present level of diagnostic equipment available to the industry, and the needs of the industry. The OEMs vehemently disagree that this preference is either negligent or wrong given the present options.

With regard to the comment regarding wiring protection, as with any component installed on the airplane, except as cited within the Configuration Deviation List contained within the Dispatch Deviations Procedures Guide, protective shields and guards are required to be installed on the airplane during revenue service. The OEMs provide wiring protection in specific cases and expect that that protection will remain on the airplane indefinitely. The reinstallation of removed equipment is a standard practices and a regulatory requirement. It is the responsibility of each operator to ensure that the design integrity of the airframe is properly maintained and to incorporate maintenance and inspection programs that follow industry best maintenance practices. The OEM's believe that, although there exists the possibility that some protection may have been inadvertently omitted on airlines undergoing extensive modification, we believe that the existing maintenance procedures in place at the airlines would dictate that such omissions would be rare. We also believe that the effects of such an omission would be minor in scope but still recognizable through normal or enhanced maintenance activities.

Operators should use the guidance provided in the forthcoming enhanced wiring inspection programs, coupled with the guidance contained within the OEM standard wiring practices documents to either identify damage caused from missing drip or heat shields, or identify the conditions that would necessitate protection. The OEMs believe that any wiring systems training program should emphasize the purpose and necessity of wiring protection systems

Finally, with regard to the comment concerning the installation of post-delivery modifications, OEM design practices, and the resulting guidance used to maintain those designs, are proprietary to the OEM. The requirement to use these practices and procedures for designs created by entities other than the OEM is inappropriate. Although the ESWPM is not considered to be a wiring standards document for designs of new installations, operators and STC applicants may refer to these guidelines in development of their installations.

As far as post-delivery modifications are concerned, Airbus is currently reviewing the ESPM content related to wire routing and segregation and will include in the ESPM guidance and recommendations in case of new wiring installation after delivery to the

aircraft. Boeing will conduct a similar review based upon the forthcoming HWG6 recommendations.

[COMMENT] Not all aircraft that need such shields have them: Ref SWR 111 and resulting TSB inspections of MD-11 fleet.

OWNER REMARKS: OEM P2

The OEMs do not understand the use of the references cited with regard to wiring protection. Previous statements concerning the installation and maintenance of wiring protection, as well as the use of OEM design standards on non-OEM designs, hold considering our confusion regarding the references. Perhaps clarification is needed.

If the comment refers to the condition whereby moisture or heat protection was not specified at the time of initial design, operators should use the guidance provided in the forthcoming enhanced wiring inspection programs, coupled with the guidance contained within the OEM standard wiring practices documents to either identify damage caused from missing drip or heat shields, or identify the conditions that would necessitate protection.

FOLLOW UP OWNER REMARKS: WG9

WG9 concurs that there is insufficient evidence of problems related to missing drip or heat shields to warrant a fleet wide campaign to check for drip shield installation. Determination of type and number of drip shields per individual aircraft configuration and post delivery modification would be complex and considered unjustified

3.2 OEM/WG8 Develop a catalog of unacceptable wire bundle configurations

Boeing - We have no plans to create and maintain a catalog of unacceptable wire bundle configurations but will ensure that the criteria for acceptable wire bundles is clear

Airbus - Airbus includes in the ESPM some examples of unacceptable wire bundle installations. In addition this subject (photo library) will be included in the training program.

Lockheed - LMCO has no plans to create and maintain a catalog of unacceptable bundle configurations. Review of the current information in the SWPM finds that examples of unacceptable practices are presented along with the acceptable configurations and practices. SIL 24-10 contains a list of applicable SB's related to specific wiring problems discovered by LMCO and the L-1011 operators. SIL 24-10 is currently in revision status for the incorporation of the intrusive and non-intrusive recommendations.

[COMMENT 1] The only OEM response received up to now shows the item to be CLOSED and GREEN, yet the actual response itself confirms there are no plans to create and maintain a catalogue of unacceptable wire bundle configurations. I cannot recall ATSRAC debating specifically the merits of creating and maintaining a catalogue of unacceptable wire bundle configurations. However, in the light of this rejection ATSRAC will need to decide how important we feel this recommendation was, and whether we are content that no action is to be taken. For my own part, I believe that this is not necessary provided that the criteria for acceptable wire bundles are made sufficiently clear. In addition, TG8 recommends that the OEM’s construct a graphical database of model and zone specific wire system faults for instructor and technician training and knowledge. For completeness, this transfers an action to the OEMs that needs to be covered by a supplemental OEM comment.

[COMMENT 2] Developing a catalog of unacceptable wire bundle configurations is a good way to learn from the mistakes of others. It is self-evident that real problems are more illustrative and instructive than theoretical ones.

OWNER REMARKS: OEM P2

The OEM responses indicated that we had no plans to create a readily accessible electronic library of unacceptable wire bundle configurations. As much of this data already exists with documentation readily available to the operator or repair station, the OEMs agreed to provide upon request representative photographs or line drawings of unacceptable wire bundle configurations for training purposes.

As far as Airbus Wiring System Training Course is concerned, representative photos of unacceptable wiring systems and/or connective devices installation/contamination will be part of the Airbus training documentation to illustrate typical problems found on the airplane.

3a2 WG7/OEM (b) Specify nondestructive testing procedures for validating wire integrity in response to undiagnosed malfunctions of cockpit electrical equipment

Boeing: (b) Troubleshooting guidance for system anomalies are contained within the specific Airplane Maintenance Manual chapter applicable to that system

Airbus - (b) The ESPM includes current technology electrical NDT testing methods. Any new testing methods that arise (e.g. HWG 9 recommendations) will be analyzed and included if appropriate

Lockheed - (b) Troubleshooting practice are contained in the specific MM chapter for each system

[COMMENT] The recommendation that there be nondestructive testing to validate the integrity of wire is quite different from recommending nondestructive testing for troubleshooting. Many electrical components are returned to the aircraft after a diagnosis of no-fault-found. Troubleshooting requires the *existence of a condition.* The recommendation was to help ensure the *absence of a condition.*

OWNER REMARKS: OEM P2

If the comment concerns the periodic testing of wiring to ensure the absence of a condition, the OEMs believe that is an inadequate method of preventing the condition from occurring. As present on-wing wiring evaluation techniques are inadequate to determine the health of the wiring on a continuous basis, the OEMs have undertaken use of continuous monitoring of the systems to determine the health of the wiring. Non-destructive testing of the wiring is reserved for determining the location of the wiring fault. These techniques account for the condition where a wiring fault occurs immediately after, or as a result of, a recommended periodic check of wiring health and the absence of a condition.

If the comment concerns the specification of techniques to identify an intermittent fault within the wiring of a anomalous system, the OEMs specify that the wiring should be inspected, both physically and through continuity, time-domain reflectometry, impedance, etc. to ensure the health of the wiring before returning the airplane to service. These procedures may be contained within the system troubleshooting sections of the airplane maintenance manual or the ESWPM. Additional troubleshooting techniques and procedures will be added to the AMM or ESWPM as they become available.

3b2	WG6/OEM	(b) Specify updated wiring separation and segregation guidelines that consider loss of multiple critical functions from a common mode failure. (c) Specify nondestructive testing procedures for validating wire integrity in response to undiagnosed malfunctions of flight critical equipment. Boeing - (b)(c) Wire separation and segregation guidelines are presently contained within the SWPM and reflect current production design standard that account for loss of multiple or redundant systems. Any changes to the standards will be reflected in future revisions to the SWPM. Troubleshooting procedures to determine the cause of any system malfunction or anomaly, including non-destructive troubleshooting of the system wiring, is contained within the specific Airplane Maintenance Manual section applicable to the system under review Airbus - (b)(c) Production design standards specify wire separation and segregation rules to provide system redundancy. These standards are described within the ESPM. Any changes to the standards will be reflected in future revisions to the ESPM. Troubleshooting procedures to determine the cause of any system malfunction or anomaly is contained within the specific Airplane Maintenance Manual section applicable to the system under review. Non-destructive testing of the system wiring is included in the ESPM Lockheed - (b) LMCO's design standards, currently, take into consideration the possible loss of multiple critical systems. Lessons learned and recommendations are to be incorporated into the SWPM revision. (c) Troubleshooting procedures are contained in the specific MM chapter. [COMMENT directed at Boeing] And outdated OWNER REMARKS: WG6/OEM P2 This comment concerns the response to the recommendation that the OEMs update wire separation and segregation guidelines to account for loss of multiple critical functions as a result of a common failure, and specify NDT procedures for undiagnosed malfunctions in the flight critical equipment. The OEM response indicated that these guidelines and procedures were presently available. The OEMs suspect that the comment relates to the adequacy of these procedures. At present there is no indication that the wire separation and segregation guidelines and NDT procedures provided by the OEMs are inadequate. However, the OEMs will review and act accordingly should ATSRAC accept recommendations that necessitate a change to the guidelines. If the comment refers to the techniques to identify an intermittent fault within the wiring of a anomalous system, the OEMs already specify that the wiring should be inspected, both physically and through continuity, time-domain reflectometry, impedance, etc. to ensure the health of the wiring before returning the airplane to service. These procedures may be contained within the system troubleshooting sections of the airplane maintenance manual or the ESWPM. Additional troubleshooting techniques and procedures will be added to the AMM or ESWPM as they become available.
5.4	OEM	(a) Specify use of in-situ indicators to identify exposure to precipitating agents or conditions – a "canary". (In particular, use in-situ litmus testing to identify exposure of wrapped construction wire to high or low pH solutions or contaminants) Boeing- Guidelines for the cleaning and conditional inspection of contaminated wiring will soon be included in the SWPM and Maintenance Planning Document applicable to the specific model airplane. A review of the wiring separation guidelines is anticipated as a result of the changes noted in the TG6 comment below

Airbus - The ESPM currently gives guidelines for the cleaning, protection and inspection of wiring. Airbus will review the wire testing requirements following any recommendations that result from HWG 9 and also HWG6. (b) Production design standards specify wire separation and segregation rules to provide system redundancy. These standards are described within the ESPM

Lockheed - LMCO will include additional guidelines, in the SWPM, that are specific to contamination identification, replacement criteria of, and cleaning of bundles. Additionally, LMCO will re-issue a SIL that addresses the cleaning of contaminants from wiring

[COMMENT 1 directed at Boeing] Not responsive to the recommendation

[COMMENT 2 directed at Boeing] Boeing's comment that "a review of the wiring separation guidelines is anticipated as a result of the changes noted in the TG6 comment below" is welcome

OWNER REMARKS: OEM P2 on comment (1) only

The OEM response stating that a review of the wiring separation guidelines is anticipated as a result of the changes expected from HWG6 indicates that the OEMs are being responsive. As indicated in the response to Item 5.1, the response to the IIWG recommendation that the OEMs specify guidelines that would result in the evaluation of wiring thought to be contaminated by acidic or alkaline materials, and the recommendation that decontamination procedures be provided, indicated that these guidelines have already or will soon be incorporated into the maintenance documentation. Although they do not assess the acidity or alkalinity of contaminants, present guidelines regarding the cleaning and/or repair of wiring account for the wide pH range of possible contaminants.

OEMs account for the environment in which wiring is expected to operate and specify wiring and components suitable for that environment. The OEMs believe that the process of a detailed visual examination, determining whether contamination exists or existed previously, whether wiring damage resulted from that contamination, procedures for the removal of contamination regardless of the pH, and repair of wiring damage, precludes the need to install Litmus paper at various locations throughout the airframe.

Wiring separation guidelines will be reviewed following any recommendations that result from HWG 6 Sub-tasks 6.7 (Wire Separation Requirements, and prospective FAR/JAR 25.1705) and 6.8 (Wiring Identification Requirements, and prospective FAR/JAR 25.1706)

PRIORITY 3 ITEMS

1.1/1.3 OEM

Update splicing practices as necessary. Consider procedure to tag locations of splices to aid in future visual inspections

PRIORITY

1 ~ WG issue

2 ~ OEM issue related to

Boeing - Boeing has reviewed our present splicing practices in light of the results of the intrusive inspection and believe that no changes are necessary at this time

Airbus - All production splices are covered in the Airbus standard documentation. While the ESPM stipulates the maximum permitted number of splices per wire. Airbus will include in ESPM guidelines to inform operators of the need to tag locations of splices

Lockheed: Per the original design, production splices are addressed in the WDM's and are physically marked on the aircraft wire bundles

[COMMENT] What is the current OEM practice for splice v. replacement of wire? Do guidelines exist?

OWNER REMARKS: OEM P3

Recommendations regarding the use of splices, including the maximum number of splices to be used within a single wire run are provided in the standard wiring practices manuals. The Boeing SWPM manual recommends replacement of the wire as preferred to splice repair, and cites a maximum of three repair splices per wire run. The Airbus ESPM manual recommends replacement of the wire as preferred to splice repair, and cites a maximum of three repair splices per wire run. For EFCS and sensitive cables, splice repair is not approved as permanent repair, when feeder splice repair is not allowed above certain gauges.

Tagging or physical identification of the splice location is not presently a recommended practice. Due to the nature of the splice installation practices, a repair splice is usually placed on the outside of the wire bundle where it is visible for conditional inspection. The system in which the wire applies may be determined by verifying the wire number, and the system to which the wire applies can be verified by consulting the Wiring Diagram Manual (WDM). Some OEMs specify the system directly on the wiring.

As splices are added to the wiring during repair, and the entire length of the wiring run may not be readily accessible to determine the total number of splices within that run, the OEMs recommend that documenting the splice location within the WDM is preferable to physically tagging the splice on the airplane. In addition, because the WDM would include information on the location of production, production repair, and in-service repair splices, and the splices would be visible on the airplane, tagging a splice for future inspection would not be necessary.

The OEMs will include within their ESWPM documents recommendations that operators record the location of repair splices for future reference.

1.3 OEM

Where appropriate utilize design practices which facilitate the repair of electrical interconnect systems without the need for splices. Develop splice vs. replacement of wire guidelines

Boeing – Boeing review of our present splicing practices, as a result of both the IIWG results and previous operator input indicates that no changes to our current practices is warranted

Airbus - Airbus review of our present splicing practices, as a result of both the IIWG results and previous operator input indicates that no changes to our current practices is warranted

Lockheed - Review of LMCO's splicing practices indicates that no changes are required

[COMMENT 1 directed at Boeing] Boeing's SWPM prohibits the use of a permanent splice in a few specific instances (see Table V in section 20-10-13). The list of instances could be increased to include much more than engine harness wire, FQIS wire, primary flight control systems, and special purpose wire or special wire types. Other prohibitions could involve the presence of proximate splices in the same harness, moisture prone areas, wire segments shorter than a specific length, etc. In these instances a replacement wire or wire segment could be specified.

[COMMENT 2 directed at Boeing] As witnessed in our tour of the Boeing wiring fabrication shop in July 2001, splices are used as well in type design applications. We saw where a Boeing harness integrated with a PSU lighting supplier via splices to each individual PSU light fixture. It is not clear to me at this point in the process, when splices are acceptable and when they should be discouraged. It would seem that for in service aircraft, we want to only allow environmental splices when the cost/downtime associated with replacing the wire is prohibitive. If we take such a stance with the aircraft operators, should we not also have standards that discourage their use in new design build applications? And to the contrary, if splices such as we saw at Boeing are safe and maintainable, should we not sanction their use for in service fleet modifications

OWNER REMARKS: OEM P3

Recommendations regarding the use of splices, including the maximum number of splices to be used within a single wire run are provided in the standard wiring practices manuals. The Boeing SWPM manual recommends replacement of the wire as preferred to splice repair, and cites a maximum of three repair splices per wire run. The Airbus ESPM manual recommends replacement of the wire as preferred to splice repair, and cites a maximum of three repair splices per wire run. For sensitive cables splice repair is not approved as permanent repair, when feeder splice repair is not allowed above certain gauges.

The prohibition of splices within these systems is due to the nature of the system operation rather than the physical location of the wire harness. Guidelines regarding the placing of splices within a wire bundle and the use of splices within a SWAMP area are already specified. Although Boeing recommends the replacement of a wire over use of a repair splice, a properly installed repair splice is an effective and permanent repair of wiring.

Airbus design practices are to use interconnect elements and production splices are minimized to specific zones where installation of connective devices is impracticable. Although Airbus recommends replacement of the wire as preferred to splice repair, a properly installed repair splice is an effective and permanent repair of wiring.

The use of splices is a necessary and effective method of branching systems during airplane manufacture. Although wire replacement rather than repair is preferred, the nature of wire routing throughout the airframe, the reduced reliability associated with wiring designs with an increased number of connectors, and the limited access to all individual wires, necessitates the use of splices for repair. The specification of which type of manufacturing splice is used in each situation is reflected within the OEM standard wiring practices documents, i.e. what is accomplished during production is permitted on in-service airplanes.

In addition, the OEMs have already or will soon begin to require the use of only environmental splices for repairs of wiring in all locations of the airplane.

As far as post-delivery modifications are concerned, Airbus is currently reviewing the ESPM content related to wire routing and segregation and will include in the ESPM guidance and recommendations in case of new wiring installation after delivery to the aircraft.

2.4 OEM

Review design and maintenance practices regarding the use heat shields. Establish on-condition criteria for the replacement of wire in heat-damaged bundles (external and internal heat). Develop and implement configuration management processes to prevent load creep that may result in circuits operating near the rated capacity and conductor heating

Boeing - Expected and actual sources of heat impinging on electrical wiring is presently taken into consideration during the design of the electrical system. Allowable wire damage criteria is presently specified in the SWPM. Boeing presently provides electrical load documents with the delivery of new airplanes and conducts electrical load analysis on in-service airplanes upon request

Airbus - Expected and actual sources of heat affecting electrical wiring is presently taken into consideration during the design of the electrical system. Allowable wire damage criteria are presently specified in the ESPM. Airbus presently provides electrical load documents (ELA) with the delivery of new airplanes. Airbus supplies the ELA in an electronic format to allow the operator to update the actual electrical load of the aircraft following post delivery modification of the aircraft

Lockheed - LMCO design practices have taken into consideration wiring in proximity to heat sources. Allowable damage to wire is specified in the SWPM. LMCO provided operators with a load analysis at delivery. It is the responsibility of the operator to update the analysis as require

[COMMENT 1 directed at Boeing] How do we reconcile the inspection report finding that heat damaged wiring is relatively common, with Boeing's response that the manufacturer presently takes into account the expected and actual sources of heat impinging on wiring? Is it part of the design that wiring should be damaged by heat? What is the long-term consequence of such a design philosophy?

[COMMENT 2, also applies to 2.4/2.5 and 2c2] From the various comments, I do not see an effort to include in the Task 6 report Part 25 Design guidelines that govern where heat shields/drip shields are to be installed. While definition by each OEM as to where such items are to be installed on a type certified airframe are provided through the maintenance delivery documentation, there is nothing for operators/STC agencies to use for after delivery changes to the aircraft. Of concern are the various interior changes done by many carriers that move galley and lavatories throughout the cabin. With these interior changes, location of wiring, potable water, and waste water lines are changing. I presently see no guidance coming that instructs when to use heat shields/drip shields when an electrical disconnect panel is now too close to the rerouted plumbing components.

[COMMENT 3 directed at Boeing]

The recommendation was made because the Working Group observed apparently heat damaged wire in areas near heat-emitting surfaces and equipment. I have no doubt that Boeing did consider heat sources when designing the electrical interconnect system. The question is whether those considerations were sufficient and whether their assumptions have stood the test of time.

[COMMENT] Section 20-10-11 correctly sites vibration, heat, cold, fuel, dirt, moisture, and hydraulic fluid as potential sources of damage to wire. Section 20-10-13, however, discusses damage assessment only in terms of traumatic damage. There is no discussion on how to identify and correct thermal or chemical degradation – the intent of this recommendation

OWNER REMARKS: OEM P3

In the case of heat impinging on wiring, protection is provided during the initial design for known or locations where heat is expected. Additional protection is provided in locations where in-service experience dictates that protection is needed. For example, Lockheed Martin requires the use of Bentley Harris type sleeving and segregation from heat producing equipment to address known heat sources. Operators are expected to identify areas of heat-damaged wiring during normal maintenance activities and take appropriate action. One appropriate action is to request that the OEM develop and provide fleet wide protection if the damage is expected to occur on other airplanes, or if the nature of the damage is considered to impugn safety.

As far as post-delivery modifications are concerned, Airbus is currently reviewing the ESPM content related to wire routing and segregation and will include in the ESPM guidance and recommendations in case of new wiring installation after delivery to the aircraft.

OEM design practices, and the resulting guidance used to maintain those designs, relate to the OEM wiring designs. The requirement to use these practices and procedures for designs created by entities other than the OEM is inappropriate. Operators, repair houses and STC applicants could and should consult the OEM guidelines in developing their after-delivery modifications, or develop their own

A review of OEM design standards, Advisory Circulars, and industry design guidelines in an effort to establish whether guidance on the placement of heat and moisture protection is presently available or can be created indicates that, while much of the information available states that wiring should be protected from heat and moisture sources, the guidance does not extend to a description as to how or when that protection should be required.

In the case where there is a constant heat source, such as within the engine nacelle or strut area, high-temperature wiring is normally specified. In cases where failure of a high-temperature component, such as a pneumatic duct, could result in hot air impinging on the wiring a heat shield is specified. Where fluids could contact wiring, or in high-humidity environments such as the area above the cabin ceilings, either a moisture barrier or drip loops within the wiring run are specified to prevent the fluids from contacting exposed conductors. Unfortunately there are no definitive requirements that can be provided to operators so that they may determine whether heat or moisture protection is missing. The necessity for such protection is determined through an evaluation of the electrical system design, the environment in which it is installed, and the nature of the adjacent systems.

In summary, as the OEM heat and moisture protection guidelines used in the design of the wiring systems indicates that this information is of a general nature, accounting for the wiring environment, the type of wiring specified for use n the area, and installation details; inclusion of design guidelines for the installation of heat and moisture barriers within the ESWPM is not practical.

Review of the OEM heat and moisture protection guidelines used in the design of the wiring systems indicates that this information is of a general nature, accounting for the wiring environment, the type of wiring specified for use in the area, and installation details; that inclusion of this information within the ESWPM is not practical.

6	OEM	Develop diagnostic technologies and techniques to identify and prevent the development of high resistance interconnects Boeing - Boeing has no plans to develop additional technologies or techniques to prevent or identify high resistance interconnects Airbus - Airbus has no plans to develop additional technologies or techniques to prevent or identify high resistance interconnects. Airbus feels that the current visual inspections guidelines presently provided in the ESPM plus any additional inspection requirements recommended by HWG 9 will be sufficient to detect this type of event Lockheed - Common wiring practices in the SWPM will prevent the development of high resistance interconnects. LMCO has no plans for the development of new technologies or techniques for the prevention of high resistance interconnects [COMMENT directed at Boeing] The only OEM response received up to now shows the item to be CLOSED and GREEN, yet the actual response itself confirms there are no plans to develop additional technologies or techniques to prevent or identify high resistance interconnects. I cannot recall ATSRAC debating specifically the merits of this particular course of action. However, in the light of this rejection ATSRAC will need to decide how important we feel this recommendation was, and whether we are content that no action is to be taken. For my own part, I believe that proper installation and environmental protection of connections and terminal blocks will prevent development of high resistance interconnects. In addition, visual indicators, such as discoloration and surface corrosion can be used as pointers towards the development of high resistance interconnect. OWNER REMARKS: OEM P3 The OEMs agree with the commenter that the proper installation of connections, terminal blocks, splices, etc. will prevent development of high resistance interconnects. The development of diagnostic technologies and techniques to either identify the potential for or development of high-resistance interconnects is not necessary given that visual indicators, such as discoloration, apparent during detailed visual inspections will identify high resistance interconnects. System monitoring will identify system effects as a result of high resistance interconnects. In addition, implementation of the EZAP program recommended by HWG9, and the inherent DET and GVI inspections that will result, should increase the frequency of which high-resistance interconnects are identified. However, the OEMs are actively either developing or evaluating wiring test equipment intended to determine the condition of wiring. The need to assess the development of high-resistance interconnects will be accounted for in this evaluation.
2a2	OEM	Investigate periodic, selective inspection and nondestructive testing of cockpit and electronics bay wiring Boeing - Boeing presently conducts periodic inspections of airplanes, including the E/E bay and flight deck. Selective inspections, as a result of in-service experience, are evaluated on a case-by-case basis Airbus - Airbus currently conducts periodic inspections of airplane wiring, including the avionics bay and flight deck. The information collected as a result of these inspections is used to improve and update, as required, the current electrical design, technology of electrical components and technical design directives

Lockheed - LMCO addresses wiring concerns utilizing Service Information Letter (SIL) 24-10. This SIL is updated periodically to include new information and concerns received. Recurring wiring related problems are addressed via Service Bulletins. Inspections and lab testing of in service wiring is not presently done due to the reduction of resources allocated for the L-1011. On aircraft wiring issues are addressed via SILs, Customer Technical Support and the Engineering Support staff

[COMMENT directed at Boeing] The response indicates an appropriate course of action whose adequacy will depend on the frequency and intensity of the inspections. If these inspections are no more frequent and no more intensive than those performed prior to our awareness of wiring issues, then the response is not adequate.

OWNER REMARKS: OEM P3

The initial recommendation was interpreted as, and the OEM response applied to, the concept of periodic sampling of the E/E bay and flight deck condition of wiring as a method of determining what additional actions were necessary to prevent the accumulation of combustible materials in these areas. The acknowledgement of ongoing assessments, in addition to the enhanced zonal inspections emanating from the EZAP, should result in an increased frequency and intensity of inspections to address the concern.

2b.3 OEM

Review design practices regarding the use of drip shields for this specific situation, investigate periodic selective inspection and non-destructive testing of wiring. Develop updated wiring separation guidelines that consider loss of multiple critical functions from a common mode failure

Boeing - Expected and actual sources of moisture impinging on electrical wiring is presently taken into consideration during the design of the electrical system. Boeing presently conducts periodic inspections of airplanes, including the E/E bay and flight deck. Selective inspections, as a result of in-service experience, are evaluated on a case-by-case basis. Wire separation and segregation guidelines are presently contained within the SWPM and reflect current production design standard that account for loss of multiple or redundant systems. Any changes to the standards will be reflected in future revisions to the SWPM

Airbus - Potential source of contamination of airplane wiring are identified during the design and development of the airplane, and appropriate protection in from of drip or heat shields are included to minimize the effects of contamination. Airbus currently conducts periodic inspection of the aircraft wiring including the avionics bay and flight deck. The information collected as a result of these inspections is used to improve and update, as required, the current electrical design, technology of electrical components and technical design directives and ESPM guidelines.

Routing, separation and attachment guidelines, as well as prevention of contamination and cleaning of noted contamination on the wiring and/or electrical components are currently included in the ESP

Lockheed - The Lockheed SWPM manual provides practices specific to SWAMP locations. Detailed Visual Inspection is the suggested inspection method for detecting wiring faults that may be related to moisture ingression. Drip shields are used throughout the SWAMP areas exclusively for the protection of wiring. It is the responsibility of each operator to ensure that the design integrity of the airframe is properly maintained and to incorporate maintenance and inspection programs that follow industry best maintenance practices

[COMMENT 1] Boeing states that “wire separation and segregation guidelines are presently contained within the SWPM and reflect current production design standard that account for loss of multiple or redundant systems.” The SWPM is referenced, but

not quoted, and the reference to the production design standard is non-specific. Section 20-10-19 of the SWPM states the following:

The airplane wiring is designed and installed:

- To prevent the propagation of the effects of electrical faults to other independent power sources
- To prevent possibility that the failure of a component in a redundant system can disable another related, redundant system
- To avoid electromagnetic interference (EMI) between electromagnetic compatibility (EMC) circuits that are not compatible.

These functional concerns do not take into account the potential fire or the potential for multiple critical systems failure. In other words it's OK to lose all primary flight control circuits simultaneously (possibly as the result of a localized fire or arc-tracking event) as long as the back-up are still functional.

Under the assumption that the critical failure mode is a simple bolted (non-intermittent) short circuit, Boeing allows the separation requirements to be relaxed if a fusible link circuit breaker is placed between the source and the co-located wires.

[COMMENT 2] Boeing represents that present wire separation and segregation guidelines already account for loss of multiple or redundant systems. The ATSRAC needs details to better determine if these guidelines provide adequate separation.

[COMMENT 3] This does not update anything. It only says we already have it covered. Also does not address wire separation.

OWNER REMARKS: OEM P3

Wire separation guidelines outlined within the OEM standard wiring practices manuals reflect those used during and certified for airplane manufacture. These guidelines reflect only a portion of the methods used to meet the requirements outlined in FAR 25-1309 which states, in part, that the equipment, systems and installations must be designed so that the occurrence of any failure condition which would prevent the continued safe flight and landing is improbable, and that the analysis must take into account the probability of multiple and undetected failures.

Although the OEM ESWPM provide guidelines on proper wire separation and segregation, it does not provide the reasons for these guidelines, nor does it provide the design standards for post-manufacture modifications. STC applicants can and should refer to the OEM guidelines when developing their modifications, but they are cautioned that the ESWPM is not intended as a design standard but, rather, for use in maintenance and repair of the OEM wiring installations.

In addition to the above, any new requirements which may arise from HWG 6 Sub-tasks 6.7 (Wire Separation Requirements), 6.6 (Wire System Safety Assessment Requirements) and 6.8 (Wiring Identification Requirements) will be analyzed and documentation will be updated if appropriate.

2b4 FAA

(b) Investigate segregation and separation of wire installed after manufacture of the aircraft

[COMMENT, also applies to 2d4] The aircraft operators would not be best suited to accomplish this recommendation. While there may be some talent at the carriers to tap, this is by and far, not one of our core competencies. I would put forth that the FAA Technical Center talent that we have been fortunate to see be assigned to this issue. This group is a better talent base to investigate this recommendation. Operators

would be able to assist with access to aircraft, carrying out testing/evaluations that technical experts deem helpful to the investigation.

OWNERS REMARKS: FAA P3

The FAA has completed the research plan for this project and acquisition process is underway. The bidding process will be full and open to all vendors

2c2 OEM

Review design practices regarding the use of drip guards for this specific situation. Investigate the use of nondestructive testing to troubleshoot suspect wire installations

Boeing - Moisture ingression prevention guidelines are specified in the SWPM and are commonly used during the production of new airplanes. Detailed visual inspection is the preferred NDT inspection method to identify the presence of or indications of moisture ingression.

Airbus - Moisture ingression prevention is presently taken into consideration during the design of the electrical system. Airbus will include in the ESPM guidance and practices to maintain the design provisions for the prevention of moisture contamination to wiring

Lockheed - The Lockheed SWPM manual provides practices specific to SWAMP locations. Detailed Visual Inspection is the suggested inspection method for detecting moisture ingression. Drip shields are used throughout the SWAMP areas exclusively for the protection of wiring. It is the responsibility of the operator to ensure the design integrity of the airframe and to incorporate maintenance and inspection programs that follow industry best maintenance practices

[COMMENT 1 directed at Boeing response] Are visual inspections sufficient to give a complete picture of whether moisture is or has been present in wiring? The intrusive inspections showed that visual inspections do not work to discern the majority of wiring flaws.

With this is mind it seems negligent and wrong to take the position that visual inspection is the “preferred NDT inspection method” knowing that it does not work to discern the majority of wiring flaws including and especially detecting flaws, nicks and cuts within a wire bundle or under clamps, loss of continuity problems, and sometimes does not reveal heat or arcing damage in wire insulation.

Though detailed visual inspections are an improvement, there are many testing procedures and devices available today that go beyond that. There should be no further delay in evaluating and incorporating proven NDTs in wire inspection and maintenance programs

Furthermore, ALPA raises the issue that not all aircraft in need have drip shields. Is this a manufacturer issue or an operator issue? Does the OEM agree with this assessment?

[COMMENT 2] From the various comments, I do not see an effort to include in the Task 6 report Part 25 Design guidelines that govern where heat shields/drip shields are to be installed. While definition by each OEM as to where such items are to be installed on a type certified airframe are provided through the maintenance delivery documentation, there is nothing for operators/STC agencies to use for after delivery changes to the aircraft. Of concern are the various interior changes done by many carriers that move galley and lavatories throughout the cabin. With these interior changes, location of wiring, potable water, and waste water lines are changing. I presently see no guidance coming that instructs when to use heat shields/drip shields

when an electrical disconnect panel is now too close to the rerouted plumbing components.

OWNER REMARKS: OEM P3

The use of general and detailed visual inspections of wiring installed in airplanes remains the preferred method of detecting actual or the potential for damage to wiring. This preference accounts for the present level of diagnostic equipment available to the industry, the needs of the industry, and the potential for undetected damage to result in failure. The OEMs vehemently disagree that this preference is either negligent or wrong given the present options. However, as stated previously, the OEMs continue to consider NDT methods other than visual inspections as a method of identifying actual or potential wiring faults.

In addition, the OEMs expect that the enhanced zonal analysis process (EZAP) will likely both determine whether general or detailed visual inspections are sufficient, and will likely result in identification of post-delivery wiring installations and specify any resultant wiring inspections.

With regard to the comment regarding wiring protection, as with any component installed on the airplane, except as cited within the Configuration Deviation List contained within the Dispatch Deviations Procedures Guide, protective shields are required to be installed on the airplane during revenue service. It is the responsibility of each operator to ensure that the design integrity of the airframe is properly maintained and to incorporate maintenance and inspection programs that follow industry best maintenance practices. Operators should use the guidance provided in the forthcoming wiring inspection programs, coupled with the guidance contained within the OEM standard wiring practices documents to either identify damage caused from missing drip or heat shields, or identify the conditions that would necessitate protection.

The OEM's believe that, although there exists the possibility that some protection may have been inadvertently omitted on airlines undergoing extensive modification, we believe that the existing maintenance procedures in place at the airlines would dictate that such omissions would be rare. We also believe that the effects of such an omission would be minor in scope but still recognizable through normal or enhanced maintenance activities.

Finally, with regard to the comment concerning the installation of post-delivery modifications, OEM design practices, and the resulting guidance used to maintain those designs, are proprietary to the OEM. The requirement to use these practices and procedures for designs created by entities other than the OEM is inappropriate. Operators, repair houses and STC applicants could consult the OEM guidelines in developing their after-delivery modifications, or develop their own, but they are cautioned that the ESWPM is not intended as a design standard but, rather, for use in maintenance and repair of the OEM wiring installations.

As far as post-delivery modifications are concerned, Airbus is currently reviewing the ESPM content related to wire routing and segregation and will include in the ESPM guidance and recommendations in case of new wiring installation after delivery to the aircraft.

2d3 OEM Review design practices regarding the use of drip guards. Investigate use of nondestructive testing to trouble-shoot suspect wire installations

Boeing - Moisture ingression prevention guidelines are specified in the SWPM and are commonly used during the production of new airplanes. Detailed visual inspection is the preferred NDT inspection method to identify the presence of or indications of moisture ingression

Airbus - Moisture ingression prevention is presently taken into consideration during the design of the electrical system. Airbus will include in the ESPM guidance and practices to maintain the design provisions for the prevention of moisture contamination to wiring

Lockheed - The Lockheed SWPM manual provides practices specific to SWAMP locations. Detailed Visual Inspection is the suggested inspection method for detecting moisture ingression. Drip shields are used throughout the SWAMP areas exclusively for the protection of wiring. It is the responsibility of the operator to ensure the design integrity of the airframe is maintained and to incorporate maintenance and inspection programs that follow industry best practices and are FAA approved

[COMMENT 1 directed at Boeing] What about poor initial design? Also, visual inspection was shown to inadequate to detect the type of flaws that water may cause. Such as insulation cracking

[COMMENT 2 directed at Boeing] Are visual inspections sufficient to give a complete picture of whether moisture is or has been present in wiring? The intrusive inspections showed that visual inspections do not work to discern the majority of wiring flaws.

With this is mind it seems negligent and wrong to take the position that visual inspection is the "preferred NDT inspection method" knowing that it does not work to discern the majority of wiring flaws including and especially detecting flaws, nicks and cuts within a wire bundle or under clamps, loss of continuity problems, and sometimes does not reveal heat or arcing damage in wire insulation.

Though detailed visual inspections are an improvement, there are many testing procedures and devices available today that go beyond that. There should be no further delay in evaluating and incorporating proven NDTs in wire inspection and maintenance programs

Furthermore, ALPA raises the issue that not all aircraft in need have drip shields. Is this a manufacturer issue or an operator issue? Does the OEM agree with this assessment?

OWNER REMARKS: OEM P3

The use of general and detailed visual inspections of wiring installed in airplanes remains the preferred method of detecting actual or the potential for damage to wiring. This preference accounts for the present level of diagnostic equipment available to the industry, the needs of the industry, and the potential for undetected damage to result in failure. The OEMs vehemently disagree that this preference is either negligent or wrong given the present options. However, as stated previously, the OEMs continue to consider NDT methods other than visual inspections as a method of identifying actual or potential wiring faults.

In addition, the OEMs expect that the enhanced zonal analysis process (EZAP) will likely both determine whether general or detailed visual inspections are sufficient, and will likely result in identification of post-delivery wiring installations and specify any resultant wiring inspections.

With regard to the comment regarding wiring protection, as with any component installed on the airplane, except as cited within the Configuration Deviation List contained within the Dispatch Deviations Procedures Guide, they are required to be installed on the airplane during revenue service. It is the responsibility of each operator to ensure that the design integrity of the airframe is properly maintained and to incorporate maintenance and inspection programs that follow industry best maintenance practices. The OEM's believe that, although there exists the possibility

that some protection may have been inadvertently omitted on airlines undergoing extensive modification, we believe that the existing maintenance procedures in place at the airlines would dictate that such omissions would be rare. We also believe that the effects of such an omission would be minor in scope but still recognizable through normal or enhanced maintenance activities.

Operators should use the guidance provided in the forthcoming wiring inspection programs, coupled with the guidance contained within the OEM standard wiring practices documents to either identify damage caused from missing drip or heat shields, or identify the conditions that would necessitate protection.

Finally, with regard to the comment concerning the installation of post-delivery modifications, OEM design practices, and the resulting guidance used to maintain those designs, are proprietary to the OEM. The requirement to use these practices and procedures for designs created by entities other than the OEM is inappropriate. However, operators and STC applicants can consult the ESWPM for guidelines in developing post-delivery modifications.

As far as post-delivery modifications are concerned, Airbus is currently reviewing the ESPM content related to wire routing and segregation and will include in the ESPM guidance and recommendations in case of new wiring installation after delivery to the aircraft.

2e3 OEM

Investigate use of nondestructive testing to trouble-shoot suspect wire installations. Review sources of potential contamination

Boeing - Presently available NDT/troubleshooting methods are provided within the specific airplane maintenance manual chapter appropriate for the system undergoing test. Prevention of contamination, and cleaning of noted contamination on the exterior of wiring will be included in the Boeing SWPM

Airbus - Airbus will review "EWIS" testing requirements following any recommendations that result from HWG 9. Prevention of contamination, and cleaning of noted contamination on the exterior of wiring and/or electrical components is currently included in the ESPM

Lockheed - Specific methods for NDT & troubleshooting are outlined in the maintenance manuals. It is the intent of LMCO to incorporate ATA Spec. 117 practices into the MM & SWPM

[COMMENT 1 directed at Boeing] All old and not near what can be done.

[COMMENT 2 directed at Boeing] The statement that Boeing will include new cleaning and contamination prevention material in the SWPM may be their only response indicating definitive action in response to IIWG recommendations. Unfortunately this response (satisfying other recommendations of other working groups) falls short of fully satisfactory. Though the general guidance in the SWPM is welcome, the recommendation had intended that manufacturers make it a practice to examine more closely model-specific sources of contamination and release service literature indicating how those systems could be adjusted or modified to minimize the potential for contamination

[COMMENT 3, also applies to 2f4] Boeing comments indicate that existing NDT methods are called out within existing maintenance manuals. I believe this recommendation is aimed at developing NDT methods to detect wiring flaws and locate within a wiring run. This also looks as if this recommendation should be assigned to FAA Tech Center such that the work being done with some of the NDT agencies can be tied to this recommendation.

OWNER REMARKS: OEM P3

The OEMs disagree that the inclusion of recommended procedures for the prevention and removal of contamination is the only action to be undertaken as a result of the IIWG recommendations. We also disagree that this action is unsatisfactory given the fact that we presently examine model-specific sources of contamination and release service literature indicating how those systems could be adjusted or modified to minimize the potential for contamination. This service literature was reviewed by industry teams responsible for accomplishing ATSRAC Tasks 1 and 2.

In addition, the OEMs expect that the EZAP, which contains specific evaluation of the actual and potential sources of contamination within a zone, would address the need for changes in maintenance or the need for a design change to preclude the possibility of subsequent contamination.

The Airbus ESPM currently provides guidelines for the cleaning of EWIS components (Chapter 20-55-00) and protection (Chapter 20-54-00) during maintenance. Any HWG7 and HWG9 recommendations will be analyzed and included if appropriate.

With regard to the recommendation concerning non-destructive testing, the OEM response considered the use of NDT for troubleshooting purposes. OEMs are presently evaluating the use of diagnostic equipment utilizing various technologies to identify actual or the potential for wiring faults.

2f4 OEM

Review design practices regarding the clamping and tying of wire bundles. Investigate use of nondestructive testing to trouble-shoot suspect wire installations

Boeing - Review of Boeing wire clamping and bundle assembly techniques is complete with no changes expected to those currently specified. Presently available NDT/troubleshooting methods are provided within the specific airplane maintenance manual chapter appropriate for the system undergoing test

Airbus - Review of Airbus wire clamping and bundle assembly techniques is complete with no changes expected to those currently specified. The ESPM currently provides electrical nondestructive testing, guidelines for the bundle correct attachment and bundle attachment repair. Airbus will review "EWIS" testing requirements following any recommendations that result from HWG 9

Lockheed - Current design practices for clamping and bundle assembly techniques are acceptable. No changes are planned at this time. Specific methods for NDT & troubleshooting are outlined in the maintenance manuals. It is the intent of LMCO to incorporate ATA Spec. 117 practices into the MM & SWPM

[COMMENT 1 directed at Boeing] No changes

[COMMENT 2 directed at Boeing] This recommendation arose from the finding of wire degradation caused by vibration. The original recommendation anticipated the need for updated design practices as a means to reduce the instances of vibration induced damage to wire bundles. The only OEM response received up to now shows the item to be CLOSED and GREEN, yet the actual response itself confirms there are no changes expected to be made in design practices regarding the clamping and tying of wire bundles. That response raises the further question of what is now different? Have the design practices changed at some point in the past in a way that will decrease the occurrence of vibration damage in the future? Alternatively, if the written practices have not changed significantly, and the practices themselves are deemed to be adequate, is there something in the way clamps and ties are installed during manufacture, or reinstalled during service, that needs to be addressed in order to reduce the instances of damaged wires in the fleet? I think ATSRAC needs to be assured that

		measures are in place to control the potential for excessive vibration damage before it can close off this item permanently. [COMMENT 3 directed at Boeing] If the intrusive inspection team found evidence of vibration initiated damage then the response from Boeing does not address the problem by stating that no changes in wire clamping of bundle assembly techniques are necessary However, the OEMs are actively either developing or evaluating wiring test equipment intended to determine the condition of wiring. OWNER REMARKS: OEM P3 OEM review of the results of the intrusive inspections indicate that proper use of present wire retention practices as outlines within the ESWPM would have prevented much of the observed vibration damage. The OEM response to the recommendation for a review of these practices indicated that no change to the present techniques was deemed appropriate. The expectation that release of an SFAR requiring that the ESWPM be included as part of the Instructions for Continued Airworthiness (FAR 25-1529, Appendix H) will ensure that operators will be using the guidelines outlined within that document, or using equivalent procedures developed using their own expertise. These ESWPM guidelines specify proper wire installation requirements, which account for minor errors or deviations. The OEMs are actively either developing or evaluating wiring test equipment intended to determine the condition of wiring.
2f5	FAA/OEM	(a) Investigate use of nondestructive testing to trouble-shoot suspect wire installations. (b) Investigate separation and segregation of wire installed after manufacture of the aircraft [COMMENT] There is clearly at present no effective definition of criteria for where a degradation of insulation becomes unacceptable. It seems that various items in the FAA R&T program will provide further information but until that is available it would be premature to press this action with operators OWNER REMARKS: FAA P3 FAA - (b) - The FAA has completed the research plan for this project and acquisition process is underway. The bidding process will be full and open to all vendors
	OEM	Boeing - (a) Presently available NDT/troubleshooting methods are provided within the specific airplane maintenance manual chapter appropriate for the system-undergoing test Airbus - (a) The ESPM currently provides electrical nondestructive testing to trouble-shoot electrical wiring. Airbus will review "EWIS" testing requirements following any recommendations that result from HWG 9 Lockheed - (a) Specific methods for NDT & troubleshooting are outlined in the maintenance manuals. It is the intent of LMCO to incorporate ATA Spec. 117 practices into the MM & SWPM. [COMMENT directed at Boeing] All old tech, is this all we can do?

OWNER REMARKS: OEM P3

This comment is in response to the OEM statement that presently available methods are specified for use in the non-destructive testing of installed wiring. In addition to the techniques presently available, OEMs are currently evaluating the use of additional diagnostic equipment utilizing various technologies to identify actual or the potential for wiring faults.

3b4	FAA	Develop and understanding of how vibration and contamination (solid and liquid) interact

The FAA is currently conducting a three-year program to address wire degradation, which includes vibration and contamination along with a variety of other degradation factors. Phase I of the project will be complete at the end of April 2002, followed by 20 months of testing, and an additional 8 months of data reduction, analysis, and modeling efforts

[COMMENT 1] As yet, this recommendation has no owner. Owing to the nature of the task I believe that it would best be achieved through an FAA R&D program. However, before any work is started I would welcome an ATSRAC debate on the issue in order to decide whether a study of the interaction between vibration and contamination would be valuable.

[COMMENT 2] Is this covered in the FAA planned work on wiring?

[COMMENT 3, also applies to 3e3] This is shown as unassigned and RED status for each area. I suspect that this is very much an unknown area to us. Our efforts in Task Group 9 to provide a maintenance program to keep the wiring free from contamination would be the preventative measure from any concerns that may arise in this area. If the working groups are having trouble assigning this task, I would defer to the FAA EAPAS effort to see if this warrants research in their view. If FAA does not pick this up, my thoughts would be to show the preventative actions from Task Group 9 as closing action on this issue

OWNER REMARKS: FAA P3

FAA is currently conducting a program to address wire degradation, which includes vibration and contamination along with a variety of other degradation factors.

3e2	OEM	Consider design modification to minimize potential for contamination

Boeing - Potential sources of contamination of airplane wiring are identified during the design and development of the airplane, and appropriate protection in the form of drip or heat shields are included to minimize the effects of contamination. When unanticipated sources of contamination are identified during service operation, additional protection is specified and available to operators through a service letter or service bulletin. In the case of general protection of wiring during unrelated maintenance, Boeing will be providing protection guidelines in an upcoming revision to the SWPM

Airbus - Potential sources of contamination of airplane wiring are identified during the design and development of the airplane, and appropriate protection in the form of drip or heat shields are included to minimize the effects of contamination. If in-service experience shows that additional protection against contamination is required, then a design modification will be developed to provide additional protection. This will be made available to operators thru a service bulletin. In the case of general protection of

wiring during unrelated maintenance, Airbus will be providing protection guidelines in an upcoming revision to the ESPM

Lockheed - Sources of contamination are taken into account during design and are addressed via SB's or SIL's when unforeseen discrepancies are discovered. LMCO's design standards, currently, take into consideration the possible loss of multiple critical systems. Lessons learned and recommendations are to be incorporated into the SWPM revision.

[COMMENT directed at Boeing] Provide details of the unrelated maintenance wire protection guidelines and timetable for its inclusion in the SWPM.

OWNER REMARKS: OEM P3

As unanticipated causes of wiring contamination are addressed on a case basis, the OEMs believe that this comment relates to the forthcoming recommendations regarding protection of wiring from damage and contamination during maintenance. Boeing is presently evaluating several methods of maintenance protection in various areas of an airplane. These recommendations must be validated with operators and repair stations before they are implemented into the SWPM. At this time a definitive schedule is not available.

The Airbus ESPM currently provides guidelines for the cleaning of EWIS components (Chapter 20-55-00) and protection (Chapter 20-54-00) during maintenance. Any HWG7 and HWG9 recommendations will be analyzed and included if appropriate.

In addition, based upon the ATSRAC and FAA recommendations that we do so, the OEMs are presently implementing notes into all service bulletins cautioning operators about the importance of protecting wiring during maintenance. Boeing anticipates release of service bulletins incorporating this note in mid-2002.

Airbus has launched corresponding actions to implement the EAPAS recommendation to include information in service data on minimizing wiring contamination during maintenance. A dedicated procedure is presently under preparation for introduction in the next available revision of the ESPM. This task will cover the recommendations and information included in ATA117. We are investigating also the possibility to introduce this Task in the AMM. As soon as this specific Task will be available, a cross-reference to the ESPM or AMM will be made in all relevant Service Bulletins.

LMCO has been adding notes to its SB’s recommending the utilization ATA Specification 117 guidelines when performing maintenance in, on or around wiring. All L-1011 operators have been supplied a copy of the specification and are urged to implement it into their maintenance programs. The revision of the LMCO SWPM will provide reference to ATA 117. Additionally, review of our Maintenance Manuals shows that more notes should be added, regarding proper techniques and the use of suggested references.

4.2 OEM

Aircraft Operators: Develop generic implementation plans for the potential retrofit of arc-fault circuit breakers onto in-service aircraft.

Boeing - Implementation of any new technology will be evaluated as it is being developed and with the input of the operators.

Airbus - Implementation for in-service aircraft will be dependant on the result of the test program

Lockheed - As AFCB technology is developed LMCO will continue to evaluate, with operators, the applicability for individual systems.

[COMMENT directed at Boeing] I appreciate Boeing's commitment to examining the potential of Arc-Fault Circuit Breakers. Boeing's efforts in this area have encouraged other OEMs, circuit breaker manufacturers, and operators to take seriously this technology.

4.3	OEM	Research and develop nondestructive testing techniques capable of identifying and locating insulation cracks. Consider using these techniques for both inspection and troubleshooting of suspect wires. Consider utilization of such techniques to establish on-condition criteria for replacement of endemic cracking wire

Boeing - We are presently conducting testing of wiring removed from service airplanes with the intent of identifying techniques to replace suspect wiring. This testing is ongoing and may result in the identification of and limits to insulation cracking

Airbus -Airbus is currently investigating possible non-destructive testing methods that will detect wire insulation damage

Lockheed - Currently, visual inspection techniques are the method utilized in determining wiring discrepancies. As new technology is developed LMCO will evaluate and recommend the use of proven, viable techniques in an effort to improve the detection of suspect wiring.

[COMMENT directed at Boeing] Wire cracking was identified as one of the most critical issues to address. Boeing's efforts in this area are appropriate and welcome

4a2	OEM	Consider local design modification to replace non-fire-retardant materials

Boeing - Specification and use of materials in the manufacture of an airplane, especially the ability of the material to self-extinguish, comply with federal regulations at the time of certification. Service experience or a change in the use of the airplane would be used to determine whether an original material should be replaced by a material meeting a different flammability standard.
Airbus - Specification and use of materials in the manufacture of an airplane, comply with federal regulations at the time of the certification. The results of the ongoing studies aimed at identifying acceptable materials will be used to determine the use of these materials in present and future airplanes

Lockheed - Materials met the current FAA flammability requirements at the time of design

[COMMENT 1 directed at Boeing] This does not address the question about current design modifications.

[COMMENT 2 directed at Boeing] ATSRAC has spent a great deal of time debating the issues surrounding the treatment of flammable materials in zones, without reaching a firm conclusion on whether materials that meet the regulations extant at the time of original certification should automatically be considered adequately fire resistant. I do not want to restart that debate here, but I would like to put down a marker that ATSRAC's conclusion on that issue should determine how vigorously design modifications to replace non fire retardant materials should be pursued. That, in turn, will determine whether the responses to Recommendation 4.a.2 can be considered acceptable or not.

[COMMENT 3 directed at Boeing] The ATSRAC is well aware that materials used in airplane manufacturing comply with federal regulations at the time of certification.

However, service experience, as illustrated by the intrusive inspections, show that some original material should be replaced with materials meeting a more current flammability standard. This is the basis for this series of recommendations that design modifications be considered to eliminate non-fire retardant materials. Boeing's comments are non responsive to the recommendations.

[COMMENT 4 directed at Boeing] The point of ATSRAC is to identify systemic safety issues with aging systems, not to write model-specific airworthiness directives. The airworthiness directive process is quite adequate for addressing unique problems with unique fixes, and it does not require the participation of unaffected parties (we don't need Boeing to help write Airbus AD's). Therefore, to insist that the certification basis is adequate unless modified by an AD is to deny the legitimacy of ATSRAC.

OWNER REMARKS: OEM P3

The OEMs agree that this issue concerns whether materials meeting flammability requirements in place at the time of initial certification should now be considered to be flammable if unproven under present certification standards. However, we do not agree with the comment that the results from the IIWG review indicate that some materials should be replaced. Identification of safety issues remains the responsibility of the FAA. Removal of materials thought to degrade the operational safety of an airplane is an appropriate response whereas removal of materials meeting a different standard from that currently in place for new airplane designs is not.

4a3 ARAC/FAA

Accelerate removal of flammable materials from the cockpit and electronics bay

ARAC/FAA - Airworthiness Directives have been issued for the metalized mylar insulation

[COMMENT 1] What about other flammable materials?

[COMMENT 2] Given the extensive period for compliance, prioritizing the removal of aluminized Mylar from the cockpit and electronics bay is not an inappropriate or inconsequential recommendation

OWNER REMARKS: FAA P3

To be provided by FAA

4b1 OEM

Specify accelerated removal of flammable materials. Specify guidelines to minimize moisture intrusion into wire bundles (e.g. specify drip shields over bundles running under lavatories). Specify guidelines to minimize moisture accumulation on or near bundles

Boeing - Prevention of contamination, and cleaning of noted contamination on the exterior of wiring will be included in the Boeing SWPM. Procedures for the use of drip loops as a method of prevention for moisture ingression into connectors is presently outlined in the SWPM. Additional guidelines for the removal of moisture accumulations within the airplane as a whole are contained within the specific AMM chapter applicable to the system or zone under review

Airbus - The results of the ongoing studies aimed at identifying and eliminating the use of flammable materials in the flight deck and E/E bay areas, will determine the Airbus required action. Moisture ingression prevention is presently taken into consideration during the design of the electrical system. Airbus will include in the ESPM guidance and practices to maintain the design provisions for the prevention of moisture contamination to wiring

Lockheed - Expanded requirements for the cleaning of and prevention of contamination will be included in the revision to the SWPM. Current SWPM guidelines address moisture ingression prevention.

[COMMENT directed at Boeing] Why not the materials? Instead of just contaminant

OWNER REMARKS: OEM P3

This comment is in regard to the response to the recommendation that the OEMs specify accelerated removal of flammable materials. The OEMs define flammable materials as the accumulation of contaminants over time rather than an assessment of the flammability of the materials used in the construction of the airplane. The OEMs support the prompt removal of flammable contaminants and recommend that operators do so and provide effective procedures for doing so. However, we do not support the identification and removal of materials that meet flammability requirements and which do not degrade the operational safety of the airplane.

4b2 OEM

Specify situation-specific wiring separation and segregation guidelines that consider loss of multiple critical functions from a common mode failure

Boeing - Wire separation and segregation guidelines are presently contained within the SWPM and reflect current production design standard that account for loss of multiple or redundant systems. Any changes to the standards will be reflected in future revisions to the SWPM

Airbus - Production design standards specify wire separation and segregation rules to provide system redundancy. These standards are described within the ESPM. Any changes to the standards will be reflected in future revisions to the ESPM

Lockheed - Current guidelines and design practices contain the requirements for bundle separation and segregation by category. Certification and design considerations have taken into account the possibility of loss of multiple functions from a common mode failure

[COMMENT directed at Boeing] No change once again

OWNER REMARKS: OEM P3

An assessment of the current wiring separation and segregation guidelines provided by the OEMs indicate that they already account for loss of multiple critical functions as a result of a common mode failure, so no changes were necessary to the guidelines to comply with the recommendation

However, any new requirements which may arise from HWG 6 Sub-tasks 6.7 (Wire Separation Requirements), 6.6 (Wire System Safety Assessment Requirements) and 6.8 (Wiring Identification Requirements) will be analyzed and documentation will be updated if appropriate.

4b5 FAA

Research and develop fire retarding and suppressing materials and systems suitable for this situation

Currently, no incorporation plan from the FAA (MJN)

[COMMENT 1] As yet, this recommendation has no owner. Owing to the nature of the task I believe that it would best be achieved through an FAA R&D program

[COMMENT 2] I think I understood this is being pursued by the FAA Fire research center but is it expected that work will be stimulated in industry to develop better materials? If current materials meet the standards there is no incentive to do so

[COMMENT 3] This is another area where it is not clear to me what the recommendation actually targets. My best guess would be that we are recommending development of better wire insulation material that is both resistant to cracking and more fire resistant? If so, this looks like a tasking for the wire industry. It may be better to refer the recommendation back to the Intrusive Inspection WG for clarification. By the coding of Red and the????? shown, it appears our working group chairs are not sure on this.

OWNER REMARKS: FAA P3

To be provided by the FAA

4c2 OEM Accelerate removal of flammable materials

Boeing - Prevention of contamination, and cleaning of noted contamination on the exterior of wiring will be included in the Boeing SWPM. Additional guidelines for the removal of accumulations of flammable materials are contained within the specific AMM chapter applicable to the system or zone under review

Airbus - Prevention of contamination, and cleaning of noted contamination on the exterior of wiring is included in the ESPM. The results of the ongoing studies aimed at identifying and eliminating the use of flammable materials, will determine the Airbus required action

Lockheed - Materials met the current FAA flammability requirements at the time of design. It is LMCO's intent to provide additional guidelines for cleaning and prevention of flammable contamination in the revision of the SWPM

[COMMENT directed at Boeing] Once again contamination only

OWNER REMARKS: OEM P3

Once again, the OEMs support the prompt removal of flammable contaminants and provide effective procedures for doing so. However, we do not support the identification and removal of materials, which meet flammability requirements and do not degrade the operational safety of the airplane.

4e2 OEM Consider design modification to minimize potential for contamination.

Boeing - Potential sources of contamination of airplane wiring are identified during the design and development of the airplane, and appropriate protection in the form of drip or heat shields are included to minimize the effects of contamination. When unanticipated sources of contamination are identified during service operation, additional protection is specified and available to operators through a service letter or service bulletin. In the case of general protection of wiring during unrelated maintenance, Boeing will be providing protection guidelines in an upcoming revision to the SWPM

Airbus - Potential sources of contamination of airplane wiring are identified during the design and development of the airplane, and appropriate protection in the form of drip or heat shields are included to minimize the effects of contamination. If in-service experience shows that additional protection against contamination is required, then a design modification will be developed to provide additional protection. This will be made available to operators thru a service bulletin. In the case of general protection of wiring during unrelated maintenance, Airbus will be providing protection guidelines in an upcoming revision to the ESPM

Lockheed - Expanded requirements for the cleaning of and prevention of contamination will be included in the revision to the SWPM

[COMMENT 1 directed at Boeing] Status quo

[COMMENT 2 directed at Boeing] Not responsive to the recommendation

OWNER REMARKS: OEM P3

The OEMs disagree that we are not responsive to the recommendation that we consider design modifications to minimize the potential for contamination. The presence of contamination may affect the operation of the system, definitely affects the ability to assess the condition of airplane wiring, and increases both unscheduled and schedule maintenance costs. The OEMs presently evaluate the possibility and effects of sources of all types of contamination and consider methods of preventing contamination to minimize the effects on the operation and maintenance of our airplanes. This policy is evident in the release of service bulletins recommending the incorporation of drip shields, heat shields, drains, etc.

4f1 OEM

Specify accelerated removal of flammable materials. Establish guidelines to ensure, and enhance where necessary, the secure installation of wire bundles

Boeing - Prevention of contamination, and cleaning of noted contamination on the exterior of wiring will be included in the Boeing SWPM. In addition, specific unique procedures for the attachment and prevention of damage to wiring in high vibration areas is presently provided in the SWPM

Airbus - Prevention of contamination, and cleaning of noted contamination e.g. lint etc. will be included in the ESPM. Airbus has specific design rules governing the attachment of wire bundles to counter the affects of vibration

Lockheed - Requirements for the cleaning of and prevention of contamination will be included in the revision to the SWPM. The SWPM contains specific requirements for bundle attachment in high vibration areas

[COMMENT 1 directed at Boeing] Once again contamination only

[COMMENT 2 directed at Boeing] Not responsive to the recommendation

OWNER REMARKS: OEM P3

Once again, the OEMs are being responsive to the recommendation in our support for the prompt removal of flammable contaminants and provide effective procedures for doing so. However, we do not support the identification and removal of materials, which meet flammability requirements and do not degrade the operational safety of the airplane.

5.1 OEM

Specify guidelines that precipitate an invasive inspection or nondestructive testing of wire bundles exposed to suspected high or low pH contaminants. Specify guidelines for decontamination procedures for wire to neutralize the effects of chemically aggressive contaminants

Boeing- Guidelines for the cleaning and conditional inspection of contaminated wiring will soon be included in the SWPM and Maintenance Planning Document applicable to the specific model airplane

Airbus - The ESPM currently gives guidelines for the cleaning, protection and inspection of wiring. Airbus will review the wire testing requirements following any recommendations that result from HWG 9 and also HWG6

Lockheed - LMCO will include additional guidelines, in the SWPM, that are specific to contamination identification, replacement criteria of, and cleaning of bundles. Additionally, LMCO will re-issue a SIL that addresses the cleaning of contaminants from wiring

[COMMENT 1 directed at Boeing] Once again contamination only

[COMMENT 2 directed at Boeing] The only OEM response received up to now shows the item to be CLOSED and GREEN. However, the response does not address the first part of the recommendation to "specify guidelines that precipitate an invasive inspection or nondestructive testing of wire bundles exposed to suspected high or low pH contaminants". Until a response is received on this point, the item should remain OPEN and YELLOW

[COMMENT 3] Guidelines for cleaning and inspecting contaminated wiring must be reflective of the intrusive inspection findings. Use of the qualifier "when unanticipated sources of contamination are identified during service operation." Leads one to conclude there have not already been unanticipated sources. The intrusive inspection report assures us there have been and there will continue to be unanticipated contamination. We can anticipate that.

[COMMENT 4 directed at Boeing] While Boeing specifically rejects the notion of assessing the caustic nature of contaminants, the recommendation that "the procedures should specify the replacement of the wiring if the contamination is suspected of entering the wiring insulation and cannot be removed through conventional cleaning procedures" is welcome.

OWNER REMARKS: OEM P3

The response to the IIWG recommendation that the OEMs specify guidelines that would result in the evaluation of wiring thought to be contaminated by acidic or alkaline materials, and the recommendation that decontamination procedures be provided, indicated that these guidelines have already or will soon be incorporated into the maintenance documentation. Although they do not assess the acidity or alkalinity of contaminants, present guidelines regarding the cleaning and/or repair of wiring account for the wide pH range of possible contaminants. The guidelines also provide procedures for an external, cleaning of the wire bundle, or an invasive cleaning/repair of the individual wires, depending on the amount or type of contamination present.

5a1 OEM

Consider design modification to eliminate non-fire-retardant materials

Boeing - Specification and use of materials in the manufacture of an airplane, especially the ability of the material to self-extinguish, comply with federal regulations at the time of certification. Service experience or a change in the use of the airplane would be used to determine whether an original material should be replaced by a material meeting a different flammability standard

Airbus -- The results of the ongoing studies aimed at identifying and eliminating the use of flammable materials in the flight deck and E/E bay areas, will determine the Airbus required action.

Lockheed - Materials met the FAA flammability requirements at the time of design

[COMMENT 1 directed at Boeing] ATSRAC has spent a great deal of time debating the issues surrounding the treatment of flammable materials in zones, without reaching a firm conclusion on whether materials that meet the regulations extant at the time of original certification should automatically be considered adequately fire resistant. I do not want to restart that debate here, but I would like to put down a marker that ATSRAC's conclusion on that issue should determine how vigorously design modifications to replace non fire retardant materials should be pursued. That, in turn, will determine whether the responses to Recommendation 4.a.2 can be considered acceptable or not.

[COMMENT 2 directed at Boeing] The ATSRAC is well aware that materials used in airplane manufacturing comply with federal regulations at the time of certification. However, service experience, as illustrated by the intrusive inspections, show that some original material should be replaced with materials meeting a more current flammability standard. This is the basis for this series of recommendations that design modifications be considered to eliminate non-fire retardant materials. Boeing's comments are non responsive to the recommendations.

OWNER REMARKS: OEM P3

Once again, the OEMs support the prompt removal of flammable contaminants and provide effective procedures for doing so. However, we do not support the identification and removal of materials that meet flammability requirements and do not degrade the operational safety of the airplane.

5a2 OEM

Accelerate removal of flammable materials.

Boeing - Prevention of contamination, and cleaning of noted contamination on the exterior of wiring will be included in the Boeing SWPM

Airbus -The results of the ongoing studies aimed at identifying and eliminating the use of flammable materials in the flight deck and E/E bay areas, will determine the Airbus required action. Contamination prevention is presently taken into consideration during the design of the electrical system. Airbus will include in the ESPM guidance and practices to maintain the design provisions for the prevention of contamination to wiring

Lockheed - Expanded requirements for the cleaning of and prevention of contamination will be included in the revision to the SWPM.

[COMMENT directed at Boeing] Once again contamination only

OWNERS REMARKS: OEM P3

Once again, the OEMs support the prompt removal of flammable contaminants and provide effective procedures for doing so. However, we do not support the identification and removal of materials that meet flammability requirements and do not degrade the operational safety of the airplane

6a1 OEM

Accelerate removal of flammable materials from the cockpit and electronics bay

Boeing - Prevention of contamination, and cleaning of noted contamination on the exterior of wiring will be included in the Boeing SWPM. Additional guidelines for the removal of accumulations of contamination are contained within the specific AMM chapter applicable to the system or zone under review

Airbus - the results of the ongoing studies aimed at identifying and eliminating the use of flammable materials in the flight deck and E/E bay areas, will determine the Airbus required action. Moisture contamination prevention is presently taken into consideration during the design of the electrical system. Airbus will include in the ESPM guidance and practices to maintain the design provisions for the prevention of moisture contamination to wiring

Lockheed - Expanded requirements for the cleaning of and prevention of contamination will be included in the revision to the SWPM

[COMMENT 1 directed at Boeing] Once again contamination only

[COMMENT 2 directed at Boeing] The ATSRAC is well aware that materials used in airplane manufacturing comply with federal regulations at the time of certification. However, service experience, as illustrated by the intrusive inspections, show that some original material should be replaced with materials meeting a more current flammability standard. This is the basis for this series of recommendations that design modifications be considered to eliminate non-fire retardant materials. Boeing's comments are non responsive to the recommendations.

OWNER REMARKS: OEM P3

As stated previously, the OEMs are responsive to the recommendation in our support of the prompt removal of flammable contaminants. We recommend that operators do so and provide effective procedures for doing so. However, we do not support the identification and removal of materials, which meet flammability requirements and do not degrade the operational safety of the airplane. We do not support the statement that the intrusive inspections indicated that some original materials should be replaced with materials meeting later flammability standards. The OEMs could not locate this conclusion or the recommendation within the IIWG report.

6b1 OEM

Accelerate removal of flammable materials. Ensure separation of wire bundles from flammable materials

Boeing - Prevention of contamination, and cleaning of noted contamination on the exterior of wiring will be included in the Boeing SWPM. Additional guidelines for the removal of accumulations of contamination are contained within the specific AMM chapter applicable to the system or zone under review

Airbus - The results of the ongoing studies aimed at identifying and eliminating the use of flammable materials in the flight deck and E/E bay areas, will determine the Airbus required action. Moisture contamination prevention is presently taken into consideration during the design of the electrical system. Airbus will include in the ESPM guidance and practices to maintain the design provisions for the prevention of moisture contamination to wiring

Lockheed - Expanded requirements for the cleaning of and prevention of contamination will be included in the revision to the SWPM

[COMMENT 1directed at Boeing] Once again contamination only

[COMMENT 2 directed at Boeing] The ATSRAC is well aware that materials used in airplane manufacturing comply with federal regulations at the time of certification. However, service experience, as illustrated by the intrusive inspections, show that some original material should be replaced with materials meeting a more current flammability standard. This is the basis for this series of recommendations that design modifications be considered to eliminate non-fire retardant materials. Boeing's comments are non responsive to the recommendations.

OWNER REMARKS: OEM P3

As stated previously, the OEMs are responsive to the recommendation in our support of the prompt removal of flammable contaminants and provide effective procedures for doing so. However, we do not support the identification and removal of materials that meet flammability requirements and do not degrade the operational safety of the airplane. We do not support the statement that the intrusive inspections indicated that some original materials should be replaced with materials meeting later flammability standards. The OEMs could not locate this conclusion or the recommendation within the IIWG report.

In regards to separation of wiring from flammable materials, the OEMs specify spatial separation requirements from materials of all types, and provide special guidelines for wiring located within flammable vapor zones. Of course, any recommendations emanating from HWG6 concerning wiring separation will be evaluated accordingly with changes noted in our documentation.

6c1 OEM

Consider design modification to minimize potential for contamination.

Boeing - Potential sources of contamination of airplane wiring are identified during the design and development of the airplane, and appropriate protection in the form of drip or heat shields are included to minimize the effects of contamination. When unanticipated sources of contamination are identified during service operation, additional protection is specified and available to operators through a service letter or service bulletin. In the case of general protection of wiring during unrelated maintenance, Boeing will be providing protection guidelines in an upcoming revision to the SWPM

Airbus - Potential sources of contamination of airplane wiring are identified during the design and development of the airplane, and appropriate protection in the form of drip or heat shields are included to minimize the effects of contamination. If in-service experience shows that additional protection against contamination is required, then a design modification will be developed to provide additional protection. This will be made available to operators thru a service bulletin. In the case of general protection of wiring during unrelated maintenance, Airbus will be providing protection guidelines in an upcoming revision to the ESPM

Lockheed - Expanded requirements for the cleaning of and prevention of contamination will be included in the revision to the SWPM.

[COMMENT directed at Boeing] But what have you learned?

OWNER REMARKS: OEM P3

The OEMs were aware of the continued potential for contamination throughout the life of the airplane, a fact that was reinforced by the results of the IIWG. The OEMs learned that the prevention and prompt removal of contamination on wiring were not being emphasized by the operators as routine maintenance of the wiring.

6d1 OEM

Consider design modification to minimize potential for contamination

Boeing - Potential sources of contamination of airplane wiring are identified during the design and development of the airplane, and appropriate protection in the form of drip or heat shields are included to minimize the effects of contamination. When unanticipated sources of contamination are identified during service operation, additional protection is specified and available to operators through a service letter or

service bulletin. In the case of general protection of wiring during unrelated maintenance, Boeing will be providing protection guidelines in an upcoming revision to the SWPM

Airbus -Potential sources of contamination of airplane wiring are identified during the design and development of the airplane, and appropriate protection in the form of drip or heat shields are included to minimize the effects of contamination. If in-service experience shows that additional protection against contamination is required, then a design modification will be developed to provide additional protection. This will be made available to operators thru a service bulletin. In the case of general protection of wiring during unrelated maintenance, Airbus will be providing protection guidelines in an upcoming revision to the ESPM

Lockheed - Sources of contamination are taken into account during design and are addressed via SB's or SIL's when unforeseen discrepancies are discovered. LMCO's design standards, currently, take into consideration the possible loss of multiple critical systems. Lessons learned and recommendations are to be incorporated into the SWPM revision

[COMMENT directed at Boeing] Guidelines for cleaning and inspecting contaminated wiring must be reflective of the intrusive inspection findings. Use of the qualifier "when unanticipated sources of contamination are identified during service operation." Leads one to conclude there have not already been unanticipated sources. The intrusive inspection report assures us there have been and there will continue to be unanticipated contamination. We can anticipate that.

OWNER REMARKS: OEM P3

The response stated that "…when unanticipated sources of contamination are identified during service operation, additional protection is specified and available to operators through a service letter or service bulletin…" The fact that the OEMs have already released such documents to provide protection from sources of contamination on in-service airplanes not anticipated during the design of the airplane, would contradict the conclusion that there have not already been unanticipated sources.

GR5 FAA

Excessive wire heating presents the risk of electrical fire or ignition of surrounding combustible materials. High resistance inter-connections where electrical heating is sufficient to damage the wire insulation are typically detected by visual inspection for embrittled, charred or missing insulation. However, the relationship of observable thermal damage to wire hot enough to hazard the aircraft is still unknown. It is recommended that the FAA conduct research to determine how best to manage this issue

AAR-433 - This is not currently part of the FAA Electrical Systems Research Program

[COMMENT] I do not recall any of the activities in the extensive FAA R&T program which address this. Did I miss it?

OWNER REMARKS: FAA P3

To be provided by the FAA

GENERAL COMMENTS

[COMMENT 1]

a. The determination was made that all wires are considered critical, but yet the Intrusive Inspection Group realized there was a definite need to categorize/separate power wires from signal wires. "Stray currents, which affect the functionality of those systems". Kapton wires (not mentioned) were advised not to be used in high current carrying cables due to arc-tracking and flashover concerns by the current Advisory Circular 25.16 . No mention of the flammability of PVC wires (Table 7.1) in flammable materials removal discussions either.

FAA Remarks

- AC 25-16 recommends that aromatic polyimide insulated wire should be avoided in installations where wires or wire bundles are expected to flex, such as landing gear harnesses.
- The AC also states that installation of this wire type in areas where it may be exposed to condensation, rain, snow, hail, ice, or slush should be carefully evaluated.
- The statement in the AC that aromatic polyimide insulated wire should not be used in high current carrying cables is used in the context that this type of wire should not be used in where flammable fluids or vapors may be present, such as fuel tanks.
- The title of Table 7-1 is “Age Related Wire Conditions.” The table identifies conditions that affect the aging of wires regardless of wire type.

b. Advisory Circular 25.16 also states that different wire types should not be routed in the same bundles due to differences in hardness. Boeing has stated they have no in-house prohibition against mixing different wire types. Clearly if ATSRAC hopes to have voluntary compliance with only Advisory Circulars being issued, something has to change. How can we choose to support some advisory material and ignore others?

FAA Remarks

- As addressed by AC 25-16, abrasion becomes a concern when wire installation allows relative movement between wires in the same bundle. Additionally, this can also be a concern when wires of different bundles cross each other and there is relative movement between the bundles. However, the AC states that testing and service history may be used to demonstrate that the mixing of wire types will not result in abrasion.
- Service history does not indicate abrasion problems for the type of wire used in aircraft applications.
- As part of the EAPAS program, the FAA is conducting a research program to evaluate concerns over mixing of wire types and how this applies to wire installed on the aircraft over its expected lifetime.

c. The summation of nearly all of the green-lighted (closed) issues could be; already considered, already being done, only needs improved housekeeping, reference to insufficiently mature technology (arc-fault circuit breakers and non-destructive test equipment), need better maintenance awareness through increased training, or will be covered by future Advisory Circulars. It has already been shown that Advisory Circulars are being ignored. Boeing thinks existing industry practices in design and maintenance are sufficient. The NTSB and the FAA have declared that current best practices are inadequate.

FAA Remarks

- In terms of tracking the status of ATSRAC recommendation, the color green indicates that the task is closed, closed with comment, or on plan (i.e., the item is expected to be completed on schedule).
- Advisory circulars are effectively used by the global aviation community as a means to show compliance to the applicable requirements.
- The FAA along with other international regulatory authorities and the aviation industry has taken a proactive approach to improve wire related requirements, advisory material, and policy. Examples include current ATSRAC Task Nos. 6-9, recently released FAA wire policy, and a best wiring practices training course that has been well received on a global scale.

d. The intent of the Intrusive Inspection Group Report was to be as politically correct as possible. This was done by softening the verbiage for example; hypothetical, plausible scenarios, no mention of arcing of aromatic polyimides, etc. The result being that without any concrete conclusions that visual inspections can't find the most common wire flaws, and that the condition of the fleet is dangerous, these type of responses are to be expected. What problem with wiring? If there is no problem then nothing needs to be done about the fleet of wiring with; 1,100 cracks per aircraft, burned conductors, arced conductors, embrittled wires, delaminated wires, etc. The whole context of the Intrusive Inspection recommendations could be summed up by saying, we have a problem. We don't have test equipment (NDT) or futuristic arc-fault circuit breakers but we sure need them. Boeing has said everything is as designed and all is well, in this report. Boeing has agreed to the drafting of Advisory Circulars that they will ignore as the ones they ignore now.

FAA Remarks

The commenter has stated an opinion.

e. The lack of wire performance testing is what allowed the dangerous condition of the fleet's wiring, along with a fit and forget maintenance attitude. We need wire performance now, as called for by the TSB in Aug 2001 and Advisory Circular 25.16 "Demonstrations of arcing on wire insulation should be allowed to progress to the point of "insulation flashover". The tests may be supported by any relevant analysis. If laboratory tests are conducted instead of airplane tests, compliance should be with FAR 25.1363".

FAA Remarks

The title of 25.1363 is “Electrical System Tests.” The purpose of this requirement is to simulate the aircraft electrical generating and distribution system by using the same equipment used in the airplane. The reason for this is to monitor the functional characteristics of the electrical system including system components and wiring under foreseeable operating conditions.

f. This report highlights what is wrong with the Intrusive Inspection Group Report. "The conclusions are not sufficiently specific to serve as mandatory design or maintenance requirements". The conclusions should have been specific in order to disallow the report received from Boeing on the recommendations.

FAA Remarks

The commenter has stated an opinion

g. Visual inspections don't work and yet we continue to call for them in enhanced zonal (visual) inspections.

FAA Remarks

Visual inspections are an important part of inspection/maintenance programs that also include wire integrity tests. To further enhance the effectiveness of inspection programs better and improved detection devices such as arc-fault circuit and enhanced fault isolation tools are being developed for future use.

[COMMENT 2]

The responses from the working groups are, in general, detailed and well researched. There was clearly much effort put into developing proactive responses to the recommendations. Most of the manufacturer-specific comments refer to Boeing because Boeing’s comments are the most complete. The absence of comments referring to other organizations should not be construed as a specific endorsement of their current practice.

by Boeing are too generic and dismissive. Boeing is justifiably proud of its products and processes, and, if fed the appropriate data, existing Boeing processes may be sufficient to safely manage the fleet of aging Boeing aircraft. There is, however, reluctance on the part of Boeing to accept the recommendations of the IIWG as data to drive

those processes. The IIWG recommendations were not the random musings of working group members, but the considered analysis of data from real aircraft – albeit few aircraft. If the IIWG observed a phenomenon and recommended a course of action, it is incumbent on the responsible parties – using their existing fleet management processes where applicable – to determine the prevalence of that phenomenon, assess the specific consequences, make specific changes to the service literature (or directly implement changes to aircraft), and alert other affected parties. Instead the majority of Boeing responses simply state that generic or specific Boeing processes and standards are currently adequate.

A proper response to recommendations would, of course, require concerted, long-term effort on the part of all parties affected. It is not likely, for instance, that any aircraft manufacturer could specify non-destructive testing for specific at-risk circuits by the conclusion of ATSRAC's current mandate. Identification of the specific circuits alone would take more time than is available. Development of the testing systems and processes would take even longer. ATSRAC is not, however, mandated to define and fully implement comprehensive solutions to aging wiring problems: It need only define and commit to an approach – full implementation (compliance new rules) may take years.

I find it hard to believe that Boeing saw fit to close all of its actions (approximately 50) with only a few generic changes to the SWPM (mainly concerning good housekeeping practice). I would like to have seen:

1) Some commitment to intensify the frequency, intensity, or focus of their in-service evaluations,
2) Specific field assessments of issues identified by the IIWG,
3) More commitment to R&D (in addition to their degradation study).

While a fully adequate response to the IIWG recommendations would be a lot of work, it is not impossible or even impractical. The IIWG recommendations are focused specifically. The conditions associated with each recommendation should allow the OEMs and operators to restrict their efforts to specific areas of the aircraft, to specific applications, or in response to specific conditions. Nondestructive testing is not, for example, recommended for indiscriminant application – its recommended application is restricted to ensure both practicality and utility. Furthermore the recommendations are identified as options, not all of which must be implemented simultaneously to ensure safety.

Boeing Remarks.

As the commenter states, Boeing is justifiably proud of its products and processes. It is also committed to making air travel, the safest mode of transportation, even safer. That is why Boeing has aggressively supported, and will continue to support the efforts of the aging systems non-structural plan. It is the right thing to do.

With respect to the comments the process used by to formulate responses to recommendations, Boeing carefully considered each and every recommendation, not just those assigned to OEMs, and formulated an appropriate reply given the information presented in both the intrusive and non-intrusive inspection reports. In many cases Boeing felt that reassignment of recommendations aimed toward the airlines were more appropriately addressed by the OEMs. In each case the Boeing responses accounted for the results emanating from the working groups, from years fleet experience, and from inputs directly from our operators. We diligently evaluated our processes when such a recommendation was made and carefully considered the need for additional research and development. The merits of each recommendation were assessed before formulating our response.

Our responses and the actions we have committed to undertake were not taken lightly. The Boeing commitment to enhance the safety of the fleet, both older airplanes and those just entering service drove our responses. We believe we are adjusting our processes, modifying our recommended actions, and undertaking additional tasks as a result of the IIWG recommendations that will further enhance the safety of wiring within the in-service fleet. Although not a complete list, Boeing is:

- Implementing changes to our wiring designs
  - Developing and providing new procedures for the maintenance and repair of wiring
  - Making changes to our certification standards
  - Developing and implementing a wiring training course
  - Updating our scheduled wiring maintenance programs, and voluntarily implementing this change on out-of-production airplanes
  - Conducting research on wire testing and wiring protection devices
  - Actively advocating the removal of flammable contaminants

- Promoting all the recommendations to our operators
- Providing fleet experiences and specific examples to the industry
- Preempting the industry by collecting wiring information separate from systems effects

[COMMENT 3]

(1) I don't know how to interpret the lack of comments under the Airbus and Lockheed Titles where OEMs are tasked as the owner of the particular recommendation. Is the Boeing position agreed upon by all three OEM participants or are we waiting for Airbus and Lockheed positions? I would be interested in seeing any position differences between the major aircraft suppliers surfaced for ATSRAC review.

development of Arc Fault Circuit Breakers thus far is very encouraging. Should this technology continue to the point of successfully detecting arcing in aircraft wiring systems and NOT cause excessive troubleshooting problems from nuisance tripping, future aircraft designs will operate with an added level of protection from on board electrical fire events? As an operator, selective installation on certain critical or problematic circuits may prove valuable in the future after case by case assessment of an airworthiness concern through the ATA's Airworthiness Concern Coordination Process.

FAA Remarks

(1) All three OEMs have now supplied comments for the majority of the recommendations. The separate OEMs positions will be consolidated into one position/plan for action and reviewed and accepted by the FAA.

(2) AFCBs appear to have the potential to be a valuable tool in the detection of arcs and prevention of damage typically associated with arching events. Currently AFCBs are being considered for non-essential systems only in order to gain service experience, collect data, and monitor their operation. When the design, installation, and operation of AFCBs reach maturity they will be considered for installation to protect wiring on all airplane systems.

APPENDIX B – INTRUSIVE INSPECTION FINAL REPORT CHAPTER 7

The following has been extracted from the Final Report of the Intrusive Inspection Working Group dated December 29, 2000:

The working group was tasked to determine the adequacy of visual inspection. Chapter 5 addressed this issue and produced the following conclusions.

- Visual inspection is an effective tool in the management of wires subject to heat damage, burning, and chafing. In high-risk situations (where less than 100% detection is inadequate), visual inspection must be combined with other means of preventing or mitigating failure.
- Visual inspection could probably not be relied upon to detect degraded repair, cracking, arcing, or delamination. Where these conditions may occur, and where the consequence of wire failure is unacceptable, other means for prevention and mitigation must be used.

Though some specific degenerative conditions cannot be directly observed, correlation of other findings with the existence of these conditions is, in some cases, possible. The subject aircraft, DC-9-2, illustrates this point well. Though most specific instances of cracking in the tail cone were not located during the on-board visual inspection, the number of other finds in this zone, and the general assessment of the inspectors of this zone, seemed to correspond well with the number of cracks eventually found by other more sensitive examination and testing.

The working group was also tasked with assessing the state of wire in aged aircraft and determining the consequence of wire degradation to aircraft safety. The first aspect of this objective was addressed in Chapter 6. Determination of the safety hazards associated with the assessed state of wiring requires additional analysis presented below.

Development Approach to Specific Recommendations

According to SAE ARP 4761 the basis for a System Safety Assessment requires knowledge of three parameters:

- Failure Condition Severity
- Failure Condition Effect
- Probability of Occurrence

In the design phase, sophisticated analysis techniques and expert judgment must be used to estimate the probability of occurrence. For well-defined systems the failure condition severity and effects are calculated in an often lengthy but conceptually simple analysis. For our analysis the probability of occurrence is relatively easy to assess from the frequency of the findings.[7] On the other hand, because our conclusions pertain to generic systems and because our findings are often latent flaws or flaw precursors, the failure condition and

[7] Assuming, of course, that our findings on six aircraft can be considered representative of the fleet of aged revenue-service aircraft. There is no assurance that this assumption is necessarily valid.

effects are harder to assess. As such the Working Group used a modified FHA referred to here as General Threat Analysis (GTA).

In the GTA *conditions* (not flaws) are assessed for severity given *plausible, hypothetical situations*[8]. Hypothetical situations involve systems characterized, not by function and design, but by a set of factors, which would aggravate the degeneration of conditions into hazardous failures. The GTA begins with the development of two lists:

- A listing of the significant degenerative wire conditions from Table 5-2 or Table 5-3.
- A listing of all generic conditions, which may aggravate – in any plausible situation – a failure associated with terminal condition of any observed degenerative condition. Note that this list does not necessarily include factors, which may have lead to or may yet advance the condition; only those factors that could make some presumed subsequent failure more or less severe.

These two lists (with expanded definitions) are presented in Table 7-1 and 7-2.

Deteriorated Repair	A currently dysfunctional wire splice assumed to have met requirements when established (e.g. a splice originally established to be environmentally sealed but no longer so). Does not include inappropriate or unacceptable repair practice.[9]
Heat Damage or burnt wire	Thermal damage to insulation resulting from the presence of elevated temperature. due to internal or external heating.
Vibration Damage/Chafing	Insulation wear (material loss) resulting from the repeated application of a force which if applied only once would not result in noticeable damage.
Cracked Insulation	A breach in the wire insulation that does not include breaches resulting from the direct physical contact or traumatic force (e.g. knife cut, or tears).
Arcing	One or more instantaneous electrical discharges evidenced by burnt spot on one or more wires and melted conductors
Delamination	The unraveling of a tape-wrapped insulation. The separation of layers of insulation in a multilayered construction.

Table 7-1: age-related wire conditions

[8] Plausible hypothetical situations will be those situations supported by the existence of data for that or a similar situation and/or the expert opinion that such situations could reasonably be expected to occur in the life of an aircraft.

[9] Such practice was assessed in the ASTF non-intrusive inspection of 81 revenue-service aircraft.

Benign Environment	Low humidity, nonflammable environment. Few or no critical system wires in bundle. Uncontaminated and secured well.
Explosive Environment	An environment where there is a reasonable expectation of the presence of an explosive combination of gases during some phase of operation.
Flammable Materials	Surrounding materials that can sustain combustion. Includes the wire insulation itself (e.g. PVC but not polyimide.).
Other critical systems	The wire in question is bundled with other wires, at least one of which supplies current or signals to systems required for safe flight.
Moisture	Normal relative humidity in excess of 90% during some phase of flight (landing, takeoff, climb, cruise, decent, approach, landing), resulting in enhanced likelihood of shorting.
Vibration	Sufficient relative motion between wires or between wires and structure to cause or accentuate intermittent shorting.
Contamination	Contamination as the result of normal operation or maintenance resulting in either enhanced flammability or likelihood of shorting.
Cockpit or Electronics Compartment	High consequence failure locations within the aircraft.
Arc Tracking Potential	The presence arc-track-susceptible materials in the bundle in conjunction with those conditions which could precipitate sustained arcing.
Potential for excessive resistance heating	Wires with high current loads may fail as the result of excessive resistive heating at repair or splice locations. This failure can evolve into severely burnt, cracked, or melted insulation on the offending wire and its neighbors. With excessive heat and bare wire at these locations, the potential for fire is high.

Table 7-2: service conditions

Tables 7-1 and 7-2 are the basis for generic fault trees used to assess consequence severity. These fault trees indicate the severity of the potential (worst case) consequence, if the fault were allowed to reach its fully degenerate state. Each branch of the fault tree terminates in one of three possible conditions.

Undesirable – any condition that might – if left uncorrected – lead to a slight reduction in safety margins, slight increase in crew workload, or inconvenience to the occupants.

Severe – any condition that might – if left uncorrected – lead to significantly reduced safety margins or functional capabilities, a significant increase in crew workload impairing crew efficiency, or substantial discomfort to occupants.

Critical- any condition that might – if left uncorrected – lead to a large reduction in safety margins or functional capabilities, higher workload or physical distress such

that the crew could not be relied upon to perform tasks accurately or completely, or adverse effects upon occupants.

The fault trees are presented in Appendix 7.1. They represent the expert judgment of the Working Group and its advisors. They are not a representation of severity derived from an analysis of data.

Combining the assumptions of the fault trees with the results in Table 5-3 we have sufficient information to assess the safety consequences of the various conditions (severity multiplied by probability of existence) as follows:

- For each unique flaw in Table 5-3 we would individually assess the severity of the condition and its probability of existence. We make recommendations for mitigation of the specific problem.
- For each infrequent condition in Table 5-3 we list and make recommendations on all conditions whose most severe aggravating factor is "critical".
- For each frequent condition in Table 5-3 we list and make recommendations on all conditions whose most severe aggravating factor is "critical" or "severe".

Recommendations resulting from this analysis suggest changes and additions to maintenance programs for wires subject to the conditions and influencing factors listed. The recommendations do not specifically document how repairs should be completed once the condition has been observed. Current best practices are sufficient in this regard. Furthermore, the working group's recommendations should not be considered a comprehensive set of design and maintenance requirements for wire installations, nor should they be considered a substitute for specific detailed analysis. Each individual wire installation requires an analysis that considers, in addition to these recommendations, application specific requirements.

Specific Recommendations

Tables 7-5-1 through 7-5-6 summarize the results of this analysis. The first column contains interacting conditions, which together with the assumed flaw result in an unacceptable situation.[10] The last column, *recommendations*, describes the scenario and its severity and lists possible remedial action(s). The possible actions are derived from the Potential Options for Prevention or Mitigation of Consequent Failure listed in Table 5-3.

The recommendations are specific options, which are neither necessarily comprehensive nor absolutely required. For any given application, a subset of the recommendations may constitute adequate intervention. For other specific applications additional intervention may be required.

In addition, the appropriate application of OEM/FAA approved practice and application of the Enhanced Zonal Inspection Program will, in almost all circumstances, result in improved safety margins. The absence of specific recommendations regarding these programs should not be interpreted as a lack of their utility to address the situations described below.

The recommendations are directed in any of the following ways:

- *To Task Group 3, Maintenance Criteria*: Any specific recommendation that could be implemented by a change in aircraft operators' organization and execution of maintenance programs.

[10] The conditions in any single row of these tables are to be considered as additive: The recommendations are for situations involving all conditions taken together. In other words, the recommendations are valid only for situations involving (or potentially involving) all conditions specified.

- *To Task Group 4, Standard Practices*: Any specific recommendation that could be implemented by - enhancement of Electrical Standard Practices Manual.
- *To Task Group 5, Training Programs*: Any specific recommendation that could be implemented by changes to training programs for aircraft technicians, mechanics or their corporate oversight, or FAA designated personnel responsible for oversight of aircraft maintenance or operation.
- *Aircraft Manufacturers*: Any recommendation whose implementation requires the development a programmatic or technical approach by the manufacturer
- *Aircraft Operators*: Any recommendation that can be proactively pursued by the operators.
- *Others*: Other recommendations that are not sufficiently specific to allow immediate implementation by one of the above organizations

Development of an effective intervention strategy based these recommendations assumes that we can anticipate the type of flaw that will hazard the aircraft. Unless a flaw type can be ruled out as impossible (e.g. delamination for non-tape-wrapped insulation) or highly unlikely (cracking in relatively new installations) all flaw types should be considered possible.

Table 7-5-1: Degraded Splice	
Situation	Recommendations
1. Any high current circuit with one of more of the conditions identified below.	This finding is relatively infrequent. Pre-emptive replacement of spliced wire with new wire or the rework of splices can minimize the potential for repairs or splices to degrade beyond acceptable limits. Any repair should be accomplished using OEM/FAA approved methods and materials appropriate for the environment (which may exceed the requirements of originally approved practice for aged aircraft). Periodic diagnostic testing (e.g. resistance evaluation, time domain reflectometry) can help to identify failing (high resistance) repairs and splices. Recommendations: Task Group 4: Update splicing practices as necessary. Consider procedure to tag locations of splices to aid in future visual inspections. Task Group 5: Update training guidelines on a regular basis to correspond to ESPM updates. Emphasize the need to inspect splices closely for obvious deterioration as well as proper materials and workmanship. Aircraft Manufacturers: Where appropriate utilize design practices which facilitate the repair of electrical interconnect systems without the need for splices. Develop splice vs. replacement of wire guidelines. Aircraft Operators: Review initial and proficiency training practices for splice installation and inspection. Ensure full awareness of approved materials and techniques. Other: The FAA should revise AC 43-13-1B to stipulates that environmental splices are the preferred method of repairing wire in both SWAMP and non-SWAMP areas.[11] Develop wiring configuration management software that will track the installation and location of splices. Develop best practices regarding the maximum number of splices permitted for various types of circuits based upon frequency and severity of potential splice failures.
1a. Potential for high resistance heating, flammable materials	Given the specified conditions, the occurrence of this fault could lead to potentially critical consequences. In this situation the potential for fire exists. Additional Recommendations: Aircraft Manufacturers: Consider updating splicing practice to reflect special considerations associated with 1) the proximity of the splice to non-fire-retardant materials and 2) the expected wire current.
1b. Potential for high resistance heating, multiple critical systems	Given the specified conditions, the occurrence of this fault could lead to potentially critical consequences. In this situation the potential exists for loss of several flight-critical systems. Additional Recommendations: Aircraft Manufacturers: Consider updating splicing practice to reflect special consideration associated with high-current carrying splices in bundles with wires supporting multiple flight-critical systems.

[11] The milspec should appropriately reference both Mil-S-81824 and Mil-T-7928. (Currently Mil-T-7928 is inappropriately referenced.)

Table 7-5-2: Heat Damaged or Burnt Wire	
Situation	Recommendations
2. Any situation with one or more of the specific conditions identified below	This finding is relatively common. Localized heat damage (from external source or internal conductor heating) on adjacent wires may make these wires particularly subject to the formation of neighboring cracks and the potential for arcing or shorting. Visual Inspection can detect some conditions. Use of in-situ nondestructive testing methods may be used to detect additional insulation faults, especially if the heat damage effects a local area with several bundles, several wires within a single bundle, or a substantial length of a single wire. Recommendations: Task Group 3: Modify the MSG3 process to include the consideration of potential heat sources when developing zonal inspection instructions Task Group 4: Insure heat shield installation and maintenance are appropriately specified. Task Group 5: Review visual indications of overheating in order to more precisely characterize symptoms of heat-degraded wire. Aircraft Manufacturers: Review design and maintenance practices regarding the use heat shields. Establish on-condition criteria for the replacement of wire in heat-damaged bundles (external and internal heat). Develop and implement configuration management processes to prevent load creep that may result in circuits operating near the rated capacity and conductor heating. Aircraft Operators: Ensure awareness of the heat-shield requirements and proper maintenance. Other: Develop diagnostic technologies and techniques to identify and prevent the development of high resistance interconnects.
2a. Flammable materials, cockpit or electronics bay.	Given the specified conditions, the occurrence of this fault could lead to potentially critical consequences. Though the specific presence of moisture or contamination (to enable short circuiting) is not necessarily anticipated in this scenario, the specified zones and installations within these zones are critical enough to warrant extra care and precaution. Additional Recommendations: Task Group 3: Investigate periodic, selective inspection and nondestructive testing of cockpit and electronics bay wiring. Aircraft Manufacturers: Investigate periodic, selective inspection and nondestructive testing of cockpit and electronics bay wiring. Aircraft Operators: Investigate periodic, selective inspection and nondestructive testing of cockpit and EE bay wiring. Accelerate removal of flammable materials from the cockpit and electronics bay.
2b. Moisture, flammable materials, multiple critical systems	Given the specified conditions, the occurrence of this fault could lead to potentially critical consequences. Effective intervention can include reduction of moisture intrusion and minimization of flammable materials in the proximity of susceptible installations. Installation of heat shielding to protect susceptible installations can eliminate or mitigate heat damage. Because embrittled wires can fail collectively, proper separation of critical system wiring is essential. Additional Recommendations: Task Group 3: Investigate periodic, selective inspection and nondestructive testing of wire bundles supporting multiple flight critical systems. Task Group 4: Insure that drip guard installation and maintenance are appropriately specified. Aircraft Manufacturers: Review design practices regarding the use of drip guards for this specific situation. For this specific situation, investigate periodic, selective inspection and nondestructive testing of wiring. Develop updated wiring separation guidelines that consider loss of multiple critical functions from a common mode failure. Aircraft Operators: For this specific situation, investigate periodic, selective inspection and

Table 7-5-2: Heat Damaged or Burnt Wire	
Situation	Recommendations
	nondestructive testing of wiring. Investigate segregation and separation of wire installed after manufacture of the aircraft.
2c. Moisture, flammable materials	Given the specified conditions, the occurrence of this fault could lead to potentially severe consequences. Effective intervention can include reduction of moisture intrusion, minimization of flammable materials in the proximity of susceptible installations, and installation of fire or heat barriers. Additional Recommendations: Task Group 4: Insure that drip guard installation and maintenance are appropriately specified. Aircraft Manufacturers: Review design practices regarding the use of drip guards for this specific situation. Investigate the use of nondestructive testing to troubleshoot suspect wire installations.
2d. Moisture, multiple critical systems	Given the specified conditions, the occurrence of this fault could lead to potentially severe consequences. Though the presence of flammable materials is not anticipated in this scenario, the potential for a common mode failure of many or all wires in a single bundle warrants extra care and precaution. Effective intervention can include reduction of moisture intrusion and installation of fire or heat barriers. Proper separation of critical systems wiring will mitigate the consequence of collective wire failure. Additional Recommendations: Task Group 3: Task Group 4: Insure that drip guard installation and maintenance are appropriately specified. Aircraft Manufacturers: Review design practices regarding the use of drip guards. Investigate use of nondestructive testing to trouble-shoot suspect wire installations. Investigate use of nondestructive testing to trouble-shoot suspect wire installations. Aircraft Operators: Investigate separation and segregation of wire installed after manufacture of the aircraft.
2e. Flammable materials or contamination, multiple critical systems	Given the specified conditions, the occurrence of this fault could lead to potentially severe consequences. The potential for a common mode failure of many or all wires in a single bundle warrants extra care and precaution. Additional Recommendations: Task Group 3: Task Group 4: Ensure that wiring separation and segregation guidelines that consider loss of multiple critical functions from a common mode failure are specified. Aircraft Manufacturers: Investigate use of nondestructive testing to trouble-shoot suspect wire installations. Review sources of potential contamination. Investigate use of nondestructive testing to trouble-shoot suspect wire installations. Aircraft Operators: - Investigate separation and segregation of wire installed after manufacture of the aircraft. Review sources of potential contamination.
2f. Flammable materials, multiple critical systems, vibration	Given the specified conditions, the occurrence of this fault could lead to potentially severe consequences. Though moisture is not anticipated in this scenario, the potential for vibration (i.e. the relative motion of partially exposed conductors) to induce a common mode failure of many or all wires in a single critical bundle warrants extra care and precaution. Effective intervention can include reducing vibration potential with additional bundle security (clamps, ties, etc) and minimizing flammable materials in the proximity of susceptible installations. Additional Recommendations: Task Group 3: Task Group 4: Ensure that wiring separation and segregation guidelines that consider loss of multiple critical functions from a common mode failure are specified. Task Group 5: Insure that training adequately addresses wire bundle segregation, clamp and

Table 7-5-2: Heat Damaged or Burnt Wire	
Situation	Recommendations
	tie best practices specifically with regard to high vibration areas. Aircraft Manufacturers: Review design practices regarding the clamping and tying of wire bundles. Investigate use of nondestructive testing to trouble-shoot suspect wire installations. Aircraft Operators: Investigate use of nondestructive testing to trouble-shoot suspect wire installations. Investigate separation and segregation of wire installed after manufacture of the aircraft.

Table 7-5-3: Vibration Damage or Chafing	
Situation	Recommendations
3. Any Situation involving one or more of the conditions identified below	This finding is relatively common. If the chafing agent is a conductive to ground or if multiple adjacent wires are chafing, short-circuiting can occur even in the absence of moisture or a conductive contaminant (i.e. through direct physical contact). Augmenting general visual inspection with a detailed or directed visual inspection in critical areas can mitigate this condition. The necessity for rework or redesign may result from identification of chronic or widespread chafing condition. An AFCB can mitigate this condition by minimizing damage and preventing electrical fire. Recommendations: Task Group 3: For these high consequence situations, specify more detailed inspection (possibly requiring some disassembly of support hardware) to ensure potential chafing problems are spotted and corrected. . Task Group 4: Develop a catalog of unacceptable wire bundle configurations. Task Group 5: Develop enhanced training to ensure proper mechanical use of OEM/FAA approved tie downs, clamps, and wire separation/segregation are used in areas were wires or cables cross or come in contact. Ensure maintenance personnel recognize potential areas of chafing. Aircraft Manufacturers: Continue development of arc-fault circuit breaker technology. Develop generic implementation plans for the potential retrofit of arc-fault circuit breakers onto in-service aircraft. Aircraft Operators: Ensure that maintenance personnel are aware of the need to verify the security of all mounting hardware (i.e. specify tactile inspection). Develop generic implementation plans for the potential retrofit of arc-fault circuit breakers onto in-service aircraft.
3a. Flammable materials or contamination, cockpit or electronics bay	Given the specified conditions, the occurrence of this fault could lead to potentially critical consequences. Wire or wire bundle chafing in the presence of flammable materials in the cockpit or electronics bay could result in wire-to-structure or wire-to-wire shorting arcing resulting in fire. Flammable contaminants increase the potential for ignition. More emphasis on cleaning and prevention of fluid contamination (e.g. drip shields) can mitigate the risks presented by contaminants and aid in the detection of chafing conditions. Nondestructive testing can detect wire chafing (after significant dielectric breakdown) and aid in repair. Additional Recommendations: Task Group 3: Develop situation-specific guidance to ensure the proper attention to protection and cleaning wire bundles. Develop guidance on the separation of wire bundles from non-fire-retardant materials. Task Group 4: Specify situation-specific standards to ensure wire bundles are properly protected and cleaned based on OEM approved practice. Specify nondestructive testing procedures for validating wire integrity in response to undiagnosed malfunctions of cockpit electrical equipment. Aircraft Manufacturers: Develop design modification to minimize potential for contamination.

Table 7-5-3: Vibration Damage or Chafing	
Situation	Recommendations
3b. Flammable materials or contamination, multiple critical systems	Given the specified conditions, the occurrence of this fault could lead to potentially critical consequences. Wire chafing in the presence of flammable materials or contaminants with wires from multiple critical systems in close proximity could result in smoke and/or fire and loss of multiple flight-critical systems. Maintaining wire segregation for critical and redundant systems can mitigate the risk of multiple system failures. More emphasis on cleaning and prevention of fluid contamination (e.g. drip shields) can mitigate the risks presented by contaminants and aid in the detection of chafing conditions. Additional Recommendations: Task Group 3: Develop situation-specific guidance to ensure the proper attention to protection and cleaning wire bundles. Develop guidance on the separation of wire bundles from non-fire-retardant materials. Task Group 4: Specify situation-specific standards to ensure wire bundles are properly protected and cleaned. Specify updated wiring separation and segregation guidelines that consider loss of multiple critical functions from a common mode failure. Specify nondestructive testing procedures for validating wire integrity in response to undiagnosed malfunctions of flight critical equipment. Aircraft Manufacturers: Develop design modification to minimize potential for contamination. Other: Develop and understanding of how vibration and contamination (solid and liquid) interact.
3c. Multiple critical systems, arc tracking potential	Given the specified conditions, the occurrence of this fault could lead to potentially critical consequences. Wire chafing with arc tracking potential and wires from critical systems in close proximity could result in arcing and propagation to other wires, smoke and/or fire, and loss of multiple critical systems which can lead to excessive crew workload. Additional Recommendations: Task Group 3: Specify guidelines to ensure the proper attention to protection and cleaning wire bundles. Develop guidance to ensure the proper attention to protection of wire bundles. Task Group 4: Specify situation-specific standards to ensure wire bundles are securely fastened and out of harm's way. Develop situation specific wiring separation guidelines that consider loss of multiple critical functions from a common mode failure. Specify nondestructive testing procedures for validating wire integrity in response to undiagnosed electrical malfunctions. Aircraft Manufacturers:
3d. Flammable materials	Given the specified conditions, the occurrence of this fault could lead to potentially severe consequences. Wire chafing in the presence of flammable materials can lead to arcing, smoke and /or in-flight fire and increased crew workload. Augmenting general visual inspection with a detailed or directed visual inspection in critical areas can mitigate this condition. Emphasis on minimizing flammable materials in close proximity to wiring can mitigate this condition. Additional Recommendations: Task Group 3: Specify guidelines on the separation of wire bundles from non-fire-retardant materials.
3e. Contamination	Given the specified conditions, the occurrence of this fault could lead to potentially severe consequences. Wire chafing in the presence of contamination can lead to arcing, smoke and /or localized. Augmenting general visual inspection with a detailed or directed visual inspection in critical areas can mitigate this condition. Emphasis on cleaning of contaminants can mitigate the risk of enhanced flammability and aids in the inspection process. Additional Recommendations: Task Group 4: Specify enhanced standards to ensure that these wire bundles are properly

Table 7-5-3: Vibration Damage or Chafing	
Situation	Recommendations
	protected and cleaned. Aircraft Manufacturer: Consider design modification to minimize potential for contamination. Other: Develop and understanding of how vibration and contamination (solid and liquid) interact.
3f. Multiple critical systems	Given the specified conditions, the occurrence of this fault could lead to potentially severe consequences. Wire chafing with wires from critical systems in close proximity can lead to arcing and loss of multiple critical systems and increased crew workload. Augmenting general visual inspection with a detailed or directed visual inspection for bundles with multiple critical systems can mitigate this condition. Maintaining wiring separation for critical and redundant systems can mitigate the risk of multiple system failures. Additional Recommendations: Task Group 4: Specify situation-specific separation and segregation guidelines specifically for this situation. Aircraft Manufacturers:
3g. Feeder cable	Given the specified conditions, the occurrence of this fault could lead to potentially severe consequences. Chafing of a primary power feeder cable can lead to loss of a primary power source and violent arcing with damage to other systems and structure. Augmenting general visual inspection with a detailed or directed visual inspection (emphasizing the special requirements for integrity and configuration of power feeder cables) can mitigate this condition. Nondestructive testing can detect wire chafing (after significant dielectric breakdown) and aid in expedient repair. Because there are relatively few power feeder cables, more sophisticated testing is practical and should be specified. Additional Recommendations: Task Group 3: Specify more detailed inspection and testing to ensure potential chafing problems are spotted and corrected. Task Group 4: Establish specific nondestructive testing protocols for power feeder cable. Establish enhanced separation requirements specifically for this situation. Aircraft Manufacturers: Aircraft Operators: Ensure awareness of best-practice considerations for feeder cables.

Table 7-5-4: Cracked Insulation	
Situation	Recommendations
4. Any situation involving one or more of the conditions identified below	This finding is relatively common. Concentrations of cracks (through to the conductor) may under special circumstances result arcing or shorting. Visual inspection cannot be relied upon to detect cracks directly, and while testing technologies can detect certain bulk changes in insulation properties, there is no reliable and convenient means of identifying cracks[12]. An AFCB can mitigate this condition by minimizing damage and preventing electrical fire. Recommendations: Aircraft Manufacturers: Continue development of arc-fault circuit breaker technology. Develop generic implementation plans for the potential retrofit of arc-fault circuit breakers onto in-service aircraft. Aircraft Operators: Develop generic implementation plans for the potential retrofit of arc-fault circuit breakers onto in-service aircraft. Other: Research and develop nondestructive testing techniques capable of identifying and locating insulation cracks. Consider using these techniques for both inspection and troubleshooting of suspect wires. Consider utilization of such techniques to establish on-condition criteria for replacement of endemic cracking wire.
4a. Flammable materials, cockpit or electronics bay	Given the specified conditions, the occurrence of this fault could lead to potentially critical consequences. Though moisture may or may not be present in this scenario, the specified zones and installations within these zones are critical enough to warrant extra care and precaution. If visual inspection is used, it should be supplemented by the removal of flammable materials from these locations. Additional Recommendations: Task Group 3: Specify accelerated removal of flammable materials. Aircraft Manufacturers: Consider local design modification to replace non-fire-retardant materials. Aircraft Operators: Accelerate removal of flammable materials from the cockpit and electronics bay. Other: Research and develop fire retarding and suppressing materials and systems for cockpit or electronics bay use.
4b. Moisture, flammable materials, multiple critical systems	Given the specified conditions, the occurrence of this fault could lead to potentially critical consequences. The potential for fire and multiple critical system failures exists. Multiple cracks in a localized area of a bundle serving multiple critical systems can also result in stray currents, which adversely affect the functionality of those systems. If visual inspection is used, it should be supplemented by efforts to eliminate the potential for moisture intrusion and the removal of flammable materials. Maintaining wiring separation for critical and redundant systems can mitigate the risk of multiple system failures. Additional Recommendations: Task Group 3: Specify accelerated removal of flammable materials. Specify guidelines to minimize moisture intrusion into wire bundles (e.g. specify drip shields over bundles running under lavatories). Specify guidelines to minimize moisture accumulation on or near bundles. Task Group 4: Specify situation-specific wiring separation and segregation guidelines that consider loss of multiple critical functions from a common mode failure. Aircraft Manufacturers: Consider design modification to enhance wire separation requirements for this specific situation. Consider local design modification to replace non-fire-retardant materials. Aircraft Operators: Accelerate removal of flammable materials.

[12] Lectromec's Deltest does identify cracks, but it requires good physical access to the entire wire length, and can be a lengthy process.

Table 7-5-4: Cracked Insulation	
Situation	Recommendations
	Other: Research and develop fire retarding and suppressing materials and systems suitable for this situation.
4c. Moisture, flammable materials	Given the specified conditions, the occurrence of this fault could lead to potentially severe consequences. If visual inspection is used, it should be supplemented by efforts to eliminate the potential for moisture intrusion and the removal of flammable materials. Additional Recommendations: Task Group 3: Specify guidelines to minimize moisture intrusion. Specify guidelines to minimize moisture accumulation on or near bundles. Aircraft Operators: Accelerate removal of flammable materials.
4d. Moisture, multiple critical systems	Given the specified conditions, the occurrence of this fault could lead to potentially severe consequences. The potential for multiple critical system failures exists. Multiple cracks in a localized area of a bundle serving multiple critical systems can also result in stray currents which adversely affect the functionality of those systems. If visual inspection is used, it should be supplemented by efforts to eliminate the potential for moisture intrusion. Additional Recommendations: Task Group 3: Specify guidelines to minimize moisture intrusion. Specify guidelines to minimize moisture accumulation on or near bundles.
4e. Contamination, multiple critical systems	Given the specified conditions, the occurrence of this fault could lead to potentially severe consequences. Concentrations of cracks (through to the conductor) can (in the presence of some conductive contaminant) result arcing or shorting. Though flammable materials may or may not be present in this scenario, the potential for combustion (with flammable contaminants) or multiple critical system failures exists. In addition, multiple cracks in a localized area of a bundle serving multiple critical systems can also result in stray currents, which adversely affect the functionality of those systems. If visual inspection is used, it should be supplemented by efforts to eliminate the potential for contamination (i.e. drip or splatter shields). Additional Recommendations: Task Group 4: Develop enhanced standards to ensure that these wire bundles are properly protected and cleaned. Aircraft Manufacturers: Consider design modification to minimize potential for contamination.
4f. Flammable materials, multiple critical systems, vibration	Given the specified conditions, the occurrence of this fault could lead to potentially severe consequences. Concentrations of large cracks (through to the conductor) can (if brought into physical contact by vibration) result arcing or shorting. In addition, vibration of cracked insulation can accelerate the degeneration of this condition. The potential for combustion or multiple critical system failures exists. In addition, multiple cracks in a localized area of a bundle serving multiple critical systems can also result in stray currents, which adversely affect the functionality of those systems. If visual inspection is used, it should be supplemented by efforts to minimize exposure to flammable materials. Additional security (clamps, ties, etc) should be used to reduce the potential for accelerated damage and failure. Additional Recommendations: Task Group 3: Specify accelerated removal of flammable materials. Establish guidelines to ensure, and enhance where necessary, the secure installation of wire bundles. Aircraft Operators: Accelerate removal of flammable materials in suspect areas.

Table 7-5-5: Delamination	
Situation	Recommendations
5. Any situation involving one or more of the conditions identified below	This finding is relatively infrequent. Delaminations (through to the conductor) may under special circumstances result arcing or shorting. Visual inspection may not be able to detect delamination. (Data on the visual detectability of delamination is very limited.) If visual inspection is used, it should be supplemented by efforts to eliminate the potential for moisture intrusion and efforts to minimize exposure to flammable materials. An AFCB can mitigate this condition by minimizing damage and preventing electrical fire. Recommendations: Task Group 3: Specify guidelines that precipitate an invasive inspection or nondestructive testing of wire bundles exposed to suspected high or low pH contaminants. Specify guidelines for decontamination procedures for wire to neutralize the effects of chemically aggressive contaminants. Aircraft Manufacturers: Continue development of arc-fault circuit breaker technology. Develop generic implementation plans for the potential retrofit of arc-fault circuit breakers onto in-service aircraft. Operators: Specify maintenance procedures and training to instruct technicians on use of techniques to identify suspect wires. Other: Specify use of in-situ indicators to identify exposure to precipitating agents or conditions – a "canary". (In particular, use in-situ litmus testing to identify exposure of wrapped construction wire to high or low pH solutions or contaminants.) Develop updated wiring separation guidelines that consider loss of multiple critical functions from a common mode failure.
5a. Flammable materials, cockpit or electronics bay	Given the specified conditions, the occurrence of this fault could lead to potentially critical consequences. Though moisture may or may not be present in this scenario, the specified zones and installations within these zones are critical enough to warrant extra care and precaution. Additional Recommendations: Aircraft Manufacturers: Consider design modification to eliminate non-fire-retardant materials. Operators: Accelerate removal of flammable materials.
5b. Moisture, flammable materials, multiple critical systems	Given the specified conditions, the occurrence of this fault could lead to potentially critical consequences. The potential for fire and multiple critical system failures exists. If visual inspection is used, it should be supplemented by efforts to eliminate the potential for moisture intrusion and the removal of flammable materials. Maintaining wiring separation for critical and redundant systems can mitigate the risk of multiple system failures. Additional Recommendations: Task Group 4: Specify situation-specific separation and segregation guidelines. Aircraft Manufacturers: Consider design modification to eliminate non-fire-retardant materials.

Table 7-5-6: Arcing	
Situation	Recommendations
6. Any situation involving one or more of the conditions identified below.	This finding is relatively infrequent. Arcing can result from degraded or damaged wire or non-environmental or degraded splices. Because visual inspection will probably not detect initial arcing, efforts should focus on minimizing wire exposure to chafing, traumatic impact during maintenance operation in the area. Use of environmental splices can reduce the potential for a hazardous arc. Use of an AFCB can mitigate the consequences of arcing. Operational procedures, including Flight Standards Information Bulletin 00/08A, can also mitigate the consequences of initial failure. Recommendations: Task Group 5: Develop guidelines that ensure that all maintenance personnel, not just electrical maintenance technicians, are made aware of those actions that could result in breached wire. Small breaches (such as those resulting from the needling of wire) should not be dismissed as inconsequential. Aircraft Manufacturers: Continue development of arc-fault circuit breaker technology. Develop generic implementation plans for the potential retrofit of arc-fault circuit breakers onto in-service aircraft. Operators: Develop generic implementation plans for the potential retrofit of arc-fault circuit breakers onto in-service aircraft. Make maintenance personnel aware of the dangers of arcing. Other: Continue research necessary to support the development of arc-fault circuit breakers and incorporate AFCB into other circuit switching devices and selected electrical components. Conduct research into other technologies that mitigate the risk of arcing.
6a. Flammable materials, cockpit or electronics bay	Given the specified conditions, the occurrence of this fault could lead to potentially critical consequences. The existence of an arcing condition in the presence of flammable materials is unacceptable. The cockpit and electronics bay warrant special attention. Elimination of flammable materials can mitigate the consequences of arcing. Additional Recommendations: Operators: Accelerate removal of flammable materials from the cockpit and electronics bay.
6b. Flammable materials, multiple critical systems	Given the specified conditions, the occurrence of this fault could lead to potentially critical consequences. The existence of an arcing condition in the presence of flammable materials is unacceptable. In addition to the fire threat, multiple critical systems may fail. Elimination or segregation of flammable materials can mitigate the consequences of arcing. Additional Recommendations: Operators: Accelerate removal of flammable materials. Ensure separation of wire bundles from flammable materials.
6c. Contamination, cockpit or electronics bay	Given the specified conditions, the occurrence of this fault could lead to potentially critical consequences. The existence of an arcing condition in the presence of flammable contaminants is unacceptable. The cockpit and electronics bay warrant special attention. Exposure of wire to fluid contaminants (e.g. water waste, hydraulic) and solid debris (e.g. drill shavings, foreign objects) must be minimized. Susceptible wire bundles should be kept free of flammable dust and lint build-up. Additional Recommendations: Aircraft Manufacturers: Consider design modification to minimize potential for contamination. Operators: Use additional precautions when performing maintenance in the cockpit and electronics bay.
6d. Contamination, multiple critical systems	Given the specified conditions, the occurrence of this fault could lead to potentially critical consequences. The existence of an arcing condition in the presence of flammable contaminants is unacceptable. Exposure of wire to fluid contaminants (e.g. water waste, hydraulic) and solid debris (e.g. drill shavings, foreign objects) must be minimized. Susceptible wire bundles should be kept free of flammable dust and lint build-up.

Table 7-5-6: Arcing	
Situation	Recommendations
	Additional Recommendations: Aircraft Manufacturers: Consider design modification to minimize potential for contamination. Operators: Use additional precautions when performing maintenance in the vicinity of wire bundles supporting multiple flight-critical systems.
6e. Multiple critical systems, arc-tracking potential	Given the specified conditions, the occurrence of this fault could lead to potentially critical consequences. Though this scenario does not assume the presence of flammable materials or contaminants, arc-tracking on a bundle with multiple critical system wires can result in multiple flight-critical system failures. Separation of critical wiring into physically separate and smaller bundles can reduce the possibility of cascading failure. Additional Recommendations: Task Group 4: Specify enhanced separation requirements for wires with known arc-tracking potential. Specify enhanced routing requirements for wires with known arc-tracking potential that prohibit or minimize hazardous conditions such as chaffing, or damage from regular activities in/about the aircraft.

General Recommendation

There are many ATSRAC supported activities that will result in great improvement to the inspection and maintenance of aircraft electrical systems. The recommendations stemming from these activities are extremely important. The following general recommendation is meant to supplement those other recommendations. This recommendation should be considered in conjunction with those recommendations without any presumption regarding priority or importance:

Inspection and maintenance personnel should be made aware of the characteristic degenerative failure modes for specific wire types. Furthermore these personnel should be made aware of the types of wire they are likely to encounter on the aircraft they maintain. Task Group 5 should implement this recommendation by including appropriate material in their proposed training curricula.

Research Recommendations of the Intrusive Inspection Working Group

The intrusive inspection project is only a first look at state of wire in aged aircraft. As with most investigative studies of this nature, it answered some questions, failed to fully answer other questions, and raised still more questions. Cognizant of the results of this project, the working group makes the following recommendations for further research:

- The FAA should fully support its commitment to its wire degradation assessment project to begin this year. With reference to this report, the degradation assessment project should attempt to explain observed or suspected – but yet unanalyzed – phenomena on the dominant aged wire types. This research should focus on characteristic failure modes and the factors that aggravate or retard degradation. The goal of such research should be a methodology that allows us to predict with a high degree of certainty the fitness for service of wire subject to a known service environment.

  As part of the degradation assessment project the FAA should analyze the effects of wire-to-wire chaffing. Wires are currently selected by the aircraft manufacturer based on their specific application and their proximity to other wires in a bundle. Maintenance and subsequent modifications may result in the mixing of wire types not anticipated during original design. There is lingering concern that wires with different insulations can damage each other if bundled together. Building upon the work of the Navy Avionics Center report TR 2333 and Airbus investigations into this issue, this suspicion should be re-examined.

  Also as part of the degradation assessment project the FAA should analyze the effects of common contaminants on wire. Special attention should be paid to corrosion control compounds.

  This follow-on effort should be fully consistent with and build upon the work presented in the Intrusive Inspection Working Group Report. In particular, the analysis of wire bundles taken from retired aircraft is an essential part of any such effort. The FAA should consider pursuing further laboratory testing per the intrusive inspection protocol on the currently available specimens. This would include:
  - Perform additional laboratory visual analysis of 747-, L1011-, and A300-specimens.
  - Perform additional laboratory tests based on original intrusive inspection laboratory test protocol.

    - Investigation of the effects of lavatory fluid contamination of PVC insulation. Also investigate other fluids/chemicals used in aircrafts.
    - Determine probable cause of the observed degenerative conditions (e.g. internal or external heating, fluid contamination, aging).
    - For PVC/Glass/Nylon, correlate the specific symptoms of aging with the mechanical and electrical properties of the insulation.
- Excessive wire heating presents the risk of electrical fire or ignition of surrounding combustible materials. High resistance inter-connections[13] where electrical heating is sufficient to damage the wire insulation are typically detected by visual inspection for embrittled, charred or missing insulation. However, the relationship of observable thermal damage to wire hot enough to hazard the aircraft is still unknown. It is recommended that the FAA conduct research to determine how best to manage this issue.
- The FAA should aggressively pursue and promote arc-fault circuit breaker development. Many of the recommendations of this report specify this as a potential option to eliminate or mitigate electrical hazards.
- The FAA should aggressively pursue and promote the development of nondestructive test equipment for aircraft wiring. Many of the recommendations of this report specify this as a potential option to eliminate or mitigate electrical hazards.
- By their very nature connectors and terminals are designed to be serviceable, and they are physically localized. This suggests that these components should be less problematic than wires, which may stretch from one end of the aircraft to the other. On the other hand their relatively frequent handling and exposure to collateral damage, make connectors, terminals, their lead wires subject to repetitive stress and accidental damage. Furthermore, experience has shown that we cannot rule-out the possibility of a fire resulting from a defective or broken connector.
  The intrusive inspection project did not fully consider connector issues. The military and commercial aviation community should sponsor efforts to scope the problem and establish research projects and maintenance guidelines to address the issue.
- Though wires and connectors are the most obvious component in electrical interconnect systems, there are others. The FAA should investigate the physical and functional integrity of any electrical system component whose failure could hazard the aircraft. This includes: circuit breakers, relays, switches, wire support and bundling systems (including conduit), shielding, ground blocks, etc.
- The working group observed wires with breaches and non-environmental splices, and found reduced insulation resistance in certain wet wires. Though the working group did not document wire bundles with numerous, collocated breaches or non-environmental splices, the possibility should be considered. In the presence of moisture this situation could result in stray electrical currents affecting multiple systems. The FAA should investigate the possibility of this situation and its potential to hazard the aircraft.

[13] Such high resistance inter-connections (e.g. splices, terminals, connectors) are a function of aging or inappropriate maintenance.

APPENDIX C – OPEN COMMITMENTS MATRIX

ACTION PLAN	OWNER	OPEN COMMITMENT
1.1	HWG7	(a) Updated splicing practices, and procedures to identify splice locations, will be added to the SWPM/ESPM following development by the OEMs. (b) The OEMs will include within their ESWPM documents recommendations that operators record the location of repair splices for future reference
1.3, 1a1	OEMs	The OEMs have already or will soon begin to require the use of only environmental splices for repairs in all locations of the airplane during production.
1.5	LMCO	Lockheed (LMCO) design requirements specify the maximum number of splices permissible for all circuits. LMCO will update and incorporate this data into the revision of the SWPM.
2.4, 2.5	Airbus Boeing	Post-delivery modifications - Airbus is currently reviewing the ESPM content related to wire routing and segregation and will include in the ESPM guidance and recommendations in case of new wiring installation after delivery to the aircraft. Boeing will conduct a similar review based upon the forthcoming HWG6 recommendations.
2b3	OEM's	Any new requirements which may arise from HWG 6 Sub-tasks 6.7 (Wire Separation Requirements), 6.6 (Wire System Safety Assessment Requirements) and 6.8 (Wiring Identification Requirements) will be analyzed and documentation will be updated if appropriate.
2b4(b) 2d4	FAA	The FAA will take action based on a review of recommendations from the HWG6 sub-group addressing wire separation issues (Task 6.7) following the submittal of ATSRAC's final report to the FAA October 2002.
2e3	Airbus Boeing	Any HWG7 and HWG9 recommendations on wiring protection will be analyzed and included if appropriate. Recommended guidelines for protection of wiring during maintenance are in development and will be included in both SWPM in the next revision(s).
3.4, 3.5	OEM's	Implementation of any new arc fault circuit breaker technology will be evaluated as it is being developed and with the input of the operators. Lockheed - as AFCB technology is

		developed LMCO will continue to evaluate, with operators, the applicability for individual systems. If found effective the OEMs will encourage the adoption of the technology.
3a2	OEM's	Additional troubleshooting procedures for validating wire integrity in response to undiagnosed malfunctions of cockpit electrical equipment will be added to the Airplane Maintenance Manual or ESWPM as they become available.
3a3, 3e2	OEM's	Boeing is presently evaluating several methods of maintenance protection in various areas of an airplane. These recommendations must be validated with operators and repair stations before they are implemented into the ESWPM. At this time a definitive schedule is not available. The Airbus ESPM currently provides guidelines for the cleaning of EWIS components (Chapter 20-55-00) and protection (Chapter 20-54-00) during maintenance. Any HWG7 and HWG9 recommendations will be analyzed and included if appropriate OEMs are presently implementing notes into all service bulletins cautioning operators about the importance of protecting wiring during maintenance. Boeing incorporated this note starting in mid-2002. Airbus has launched corresponding actions to implement the EAPAS recommendation to include information in service data on minimizing wiring contamination during maintenance. A dedicated procedure is presently under preparation for introduction in the next available revision of the ESPM. This task will cover the recommendations and information included in ATA Specification 117. Airbus is investigating also the possibility to introduce this Task in the AMM. As soon as this specific Task will be available, a cross-reference to the ESPM or AMM will be made in all relevant Service Bulletins. Lockheed has been adding notes to its SB's recommending the utilization ATA Specification 117 guidelines when performing maintenance in, on or around wiring. All L-1011 operators have been supplied a copy of the specification and are urged to implement it into their maintenance programs. The revision of the LMCO SWPM will provide reference to ATA specification 117. Additionally, review of their Maintenance Manuals shows that more notes should be added, regarding proper techniques and the use of suggested references.
3b3, 3e2	OEM's	In the case of general protection of wiring during unrelated maintenance, OEMs will provide protection guidelines in future revisions to their ESWPM. Boeing is presently evaluating several methods of maintenance protection in various areas of an airplane. These recommendations must be validated with operators

		and repair stations before they are implemented into the SWPM. At this time a definitive schedule is not available. Any HWG7 and HWG9 recommendations on cleaning of EWIS components will be analyzed and included if appropriate
3c2	OEM's	Any new testing methods that arise (e.g. HWG 9 recommendations) for validating wire integrity in response to undiagnosed electrical malfunctions will be analyses and included if appropriate.
4b5	FAA	A request has been sent to the FAA Fire Research Program for consideration of the recommended action. The Aging Electrical Systems Research Program and Fire Research Program will coordinate an appropriate response.
4c1	Airbus	Airbus will include in the ESPM guidance and practices to maintain the design provisions for the prevention of moisture contamination to wiring.
4f2	LMCO	Expanded requirements for the cleaning of and prevention of contamination will be included in the revision to the ESWPM.
5.1	Boeing LMCO	Guidelines for the cleaning and conditional inspection of contaminated wiring will soon be included in the Boeing/Lockheed ESWPM (and in the Maintenance Planning Document for Boeing airplanes) applicable to the specific model airplane. Additionally, Lockheed will re-issue a SIL that addresses the cleaning of contaminants from wiring.
5a2	OEM's	Prevention of contamination, and cleaning of noted contamination on the exterior of wiring will be included in the manufacturers ESWPM. The results of the ongoing studies aimed at identifying and eliminating the use of flammable materials in the flight deck and E/E bay areas, will determine if any further OEM action is required.
GR5	FAA	Relationship of observable thermal damage to wire hot enough to hazard the aircraft - the FAA will review of service data to establish the scope of the problem and the necessity and/or scope of follow-on activity
GR8, GR9 & GR10	FAA	Performance assessment of aging EWIS components (other than circuit breakers) will begin in 2003 pending availability of adequate funds for this effort.