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DEPARTMENT OF DEFENSE HANDBOOK

ELECTRICAL WIRING INTERCONNECT SYSTEM (EWIS) INTEGRITY PROGRAM

This handbook is for guidance only.
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AMSC N/A **AREA SESS**

FOREWORD

1. This handbook is approved for use by all Departments and Agencies of the Department of Defense.

2. The purpose of this handbook is to establish Mechanical Equipment and Subsystems Integrity Program (MECSIP) tasks for the development, acquisition, modification, operation, sustainment, and service life extension of an aircraft Electrical Wiring Interconnect System (EWIS). This handbook consists of a series of recommendations which, when applied, will promote the continued operational safety, suitability, and effectiveness (OSS&E) of the EWIS systems throughout all phases of the aircraft's life.

3. Comments, suggestions, or questions on this document should be addressed to AFLCMC/ENRS, 2145 MONAHAN WAY, WRIGHT-PATTERSON AFB OH 45433-7017; or e-mailed to AFLCMC/EN_EZ Engineering Standards. Since contact information can change, you may want to verify the currency of this address information through use of the ASSIST Online database at https://assist.dla.mil.

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1 SCOPE

1.1 Purpose.

This handbook provides weapons systems program offices a systematic process to assess an aircraft Electrical Wiring Interconnect System (EWIS) for overall condition, service life extension, and continued airworthiness. It aligns with the Mechanical Equipment and Subsystems Integrity Program (MECSIP) (see MIL-STD-1798) and makes extensive use of lessons learned from EWIS-related military, industry, and Federal Aviation Administration (FAA) Advisory Circulars (ACs) concerned with maintaining aircraft airworthiness. It contains a framework to achieve and maintain the physical and functional integrity of the EWIS. This process should be tailored to meet specific platform, program office, system and/or subsystem requirements or constraints. The process and core tasks should also be tailored relative to platform status: whether in design, newly fielded, or based on years in sustainment. A program's use of this process should provide the information necessary to initiate the appropriate trades relative to the cost of modification or integrity initiatives versus required performance, maintenance and mission impact, total operating cost, and aircraft availability. This handbook is for guidance only and cannot be cited as a requirement.

1.2 Background.

The capability of any military force depends on the mission effectiveness and operational readiness of its weapon systems. A major factor that impacts readiness and mission reliability is the integrity (including durability, safety, reliability, and supportability) of the individual systems and equipment which comprise the total weapon system. The EWIS powers and interconnects aircraft subsystems and enables the aircraft to complete missions safely and reliably. This handbook provides a process to assess and maintain the airworthiness of the EWIS as defined in MIL-STD-1798; and MIL-HDBK-516, Airworthiness Certification Criteria. An examination of United States Air Force (USAF) mishaps over a ten-year period shows 53 percent of electrically-related mishaps are associated with wire conductors, connectors, distribution panels, or circuit breakers[1], which are major components in the EWIS. There were electrical fires or loss of critical circuits in many cases. These can lead to loss of crew or aircraft, crew injuries, aircraft damage, emergency action by the crew, and the loss of mission.

In 1999, the FAA initiated programs to address commercial aircraft EWIS integrity concerns after electrical systems were implicated in several, high-profile aircraft accidents. The FAA outlined a program to address the service life of aircraft wiring in transport aircraft and to establish the condition of aging wiring system components and validate the adequacy of visual inspections. The FAA's Aging Transport Systems Rulemaking Advisory Committee (ATSRAC) was tasked to characterize commercial EWIS integrity, and recommend actions to assess EWIS airworthiness. The ATSRAC found evidence of aging wiring, materials degradation, and inadequate installation and maintenance practices. Implementation of the ATSRAC recommendations is a major part of the FAA's Enhanced Airworthiness Program for Airplane Systems (EAPAS) (FAA Aging Nonstructural Systems Research, Christopher D. Smith, Manager, Aging Nonstructural Systems Research FAA, and William J. Hughes Technical Center). This handbook leverages FAA EWIS ACs and applies them in a tailored form to military aircraft electrical systems.

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[1] (A. Cooley, "Survey of Electrical Failures in Aircraft Mishaps," Paper at Third Joint FAA/DoD/FAA Conference on Aging Aircraft, September 1999, Albuquerque NM)

Maintenance and engineering communities will be able to use this handbook to facilitate fact-based decisions in regard to the condition of EWIS components, remaining EWIS life, and its continued airworthiness.

1.3 Approach.

The FAA has developed and implemented a process over the last ten years to conduct EWIS assessments on commercial transport aircraft. This process uses many of the principles and processes outlined in the FAA EWIS guidance documents and tailors them for a military system. The approach is to promote the integrity of the EWIS system with focus on the following:

a. Emphasis on realistic integrity requirements which will reduce EWIS system failures; such as occur during operational service life, maintenance, and environmental exposure;

b. Development of sustainment requirements (including maintenance and inspection) based on the results of analytical processes; and

c. Implementation of force management policies and procedures to ensure training and technical data continuity.

The overall process for the EWIS risk assessment is shown on figure 1.

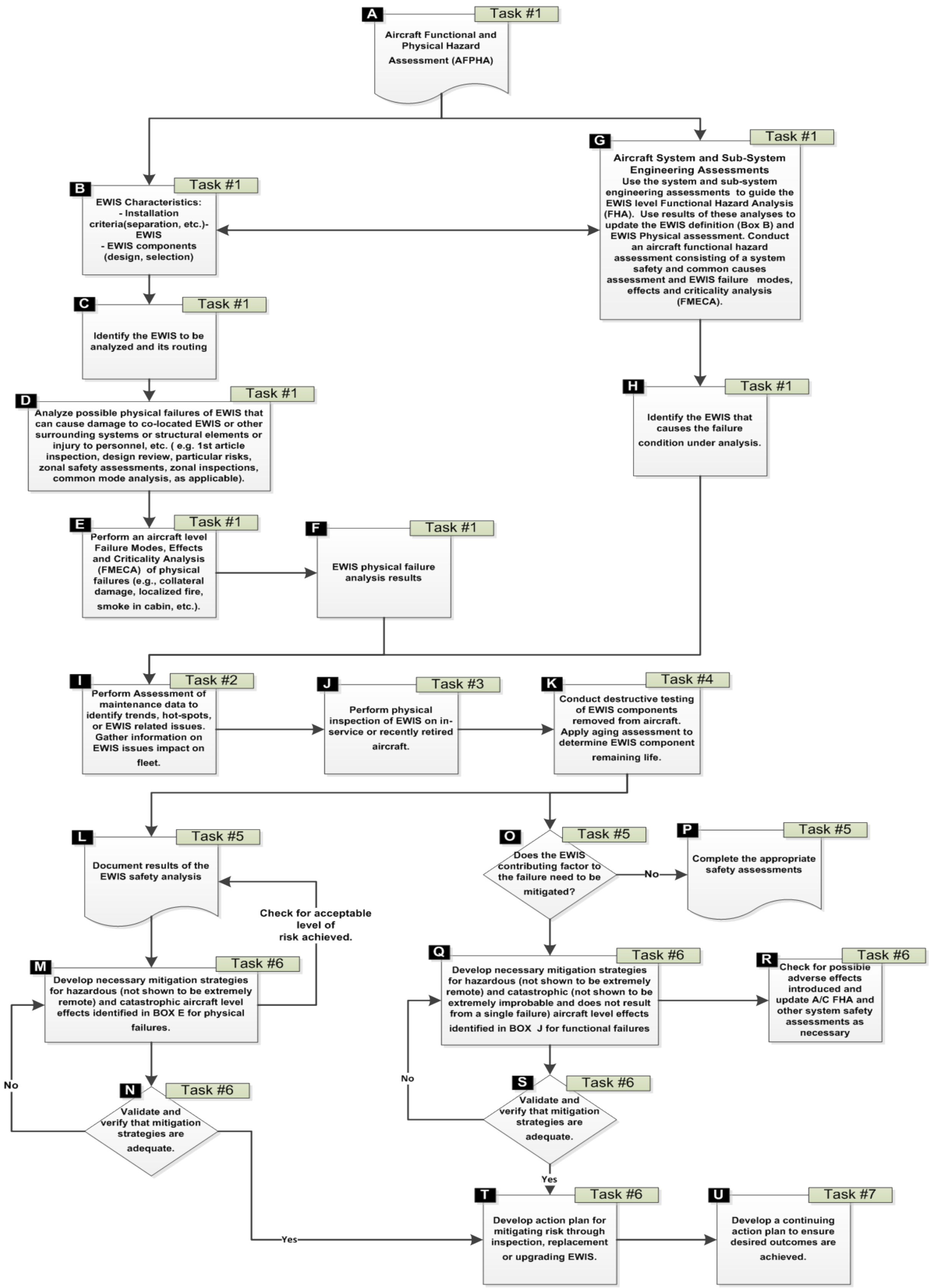


FIGURE 1. Process flow for risk assessment.

1.4 Program overview.

This program is based on the highly-successful Aircraft Structural Integrity Program (ASIP) (see MIL-STD-1530) first employed in the late 1950's. This handbook captures the generic features of ASIP and builds upon the evolution and experiences gained over the last five decades. The EWIS program evolved from the FAAs "Aging Aircraft Plan". In 1998, a series of studies examined in-service and retired commercial airliners in the first systematic effort to look at the state of aircraft wiring. The findings showed that wire degradation and failure had multiple causes and were not related solely to age.

The Enhanced Airworthiness Program for Airplane Systems (EAPAS), FAA AC 25-27A, was developed to communicate the Agency's own strategies for improved aircraft safety by emphasizing the integrity of the EWIS.

Application of the principals of this handbook will identify critical EWIS paths and degradation or damage which can then be scheduled for inspection, repair, or replacement. Implementation of the identified maintenance actions—such as inspection, repair, overhaul, replacement of parts, and preservation—will reduce EWIS functional failures and EWIS electrical fires, increase safe operation of the aircraft, increase aircraft availability, and reduce overall system life cycle costs.

This handbook is divided into seven core tasks which follow the processes outlined in military wiring-related documents and the FAA EWIS-related ACs.

1.5 Applicability.

This handbook applies to all systems and components which comprise an aircraft EWIS.

For the purposes of this handbook, "EWIS" denotes any wire, fiber optic link, wiring or fiber device, or a combination of these items (including terminations) installed in any area of the aircraft for the purpose of transmitting electrical energy, signals, or data between two or more electrical end points. The term "wire" denotes bare or insulated wire used for the purpose of electrical energy transmission, grounding, or bonding. This includes electrical cables, coaxial cables, ribbon cables, power feeders, and databuses. Fiber optic wires and associated components are also included in the assessment. Line replaceable units (LRUs)/Weapons Replaceable Assemblies (WRAs) are included in the assessment process only to determine the impact of an EWIS fault and the potential impact on system reliability. The EWIS components inside LRUs/WRAs are not considered part of this assessment. This assessment includes, but is not limited to:

1. Wires, harnesses, and cables
2. The termination point on electrical wires, including bus bars, external relays, switches and passive external components (resistors, diodes, capacitors), junction boxes, contactors, terminal blocks, and terminal boards
3. Circuit protection devices such as circuit breakers, fuses, and other current limiting devices
4. Connectors and connector accessories
5. Shield termination devices
6. Electrical grounding and bonding devices and their associated connections
7. Electrical splices and termination devices such as terminal lugs
8. Materials used to provide additional protection for wires, including wire insulation, wire sleeving, and conduits
9. Shields or braids

10. Clamps and other devices used to route and support the wire bundle (primary support restraint devices)
11. Secondary wiring restraint devices (cable ties, tying tape, etc.)
12. Labels or other means of identification
13. Pressure seals maintaining environmental separation between zones
14. EWIS components inside shelves, panels, racks, junction boxes, distribution panels, and back-planes of equipment racks including, but not limited to, circuit board back-planes, wire integration units, and external wiring of equipment
15. Exclusions are wiring and components inside, and external components directly attached to, avionic boxes and not serving as an electrical interface to the aircraft (see MIL-HDBK-454).

2 APPLICABLE DOCUMENTS

2.1 General.

The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

2.2 Government documents

2.2.1 Specifications, standards, and handbooks.

The following specifications, standards, and handbooks form a part of this document to the extent specified herein.

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-DTL-38999	Connectors, Electrical, Circular, Miniature, High Density, Quick Disconnect (Bayonet, Threaded, and Breech Coupling), Environment Resistant, Removable Crimp and Hermetic Solder Contacts
MIL-DTL-81381	Wire, Electric, Polyimide-Insulated, Copper or Copper Alloy
MIL-L-87177	Lubricants, Water Displacing, Synthetic

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-882	System Safety
MIL-STD-1530	Aircraft Structural Integrity Program (ASIP)
MIL-STD-1678	Fiber Optic Cabling Systems Requirements and Measurements
MIL-STD-1798	Mechanical Equipment and Subsystems Integrity Program

DEPARTMENT OF DEFENSE HANDBOOKS

MIL-HDBK-516	Airworthiness Certification Criteria
MIL-HDBK-522	Guidelines for Inspection of Aircraft Electrical Wiring Interconnect Systems
MIL-HDBK-683	Statistical Process Control (SPC) Implementation and Evaluation Aid

(Copies of these documents are available online at https://assist.dla.mil/quicksearch/ or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia PA 19111-5094; [215] 697-2664 USA.)

2.2.2 Other Government documents, drawings, and publications.

The following other Government documents, drawings, and publications form a part of this document to the extent specified herein.

TECHNICAL MANUALS AND ORDERS

NAVAIR 01-1A-505-1/ USAF TO 1-1A-14/ USA TM 1-1500-323-24-1	Installation and Repair Practices, Volume 1 Aircraft Electric and Electronic Wiring

Each Service issues a dash 2, dash 3, and dash 4 version of this Joint Technical Manual:

NAVAIR 01-1A-505-2	Circular Connectors
NAVAIR 01-1A-505-3	Rectangular Connectors
NAVAIR 01-1A-505-4	Fiber Optic Cabling
USAF TO 1−1A−14-2	Circular Connectors
USAF TO 1−1A−14-3	Rectangular Connectors
USAF TO 1−1A−14-4	Fiber Optic Cabling
USA TM 1−1500−323−24−2	Circular Connectors
USA TM 1−1500−323−24−3	Rectangular Connectors
USA TM 1−1500−323−24−4	Fiber Optic Connectors .

(Requests by qualified users of these US Navy documents should be addressed to the Naval Air Technical Data and Engineering Service Center, NAS North Island, Bldg 90, PO Box 357031, San Diego CA 92135-7031 USA; https://mynatec.navair.navy.mil.)

(Approved users may access these US Air Force documents in the Enhanced Technical Information Management System (ETIMS), located at “Air Force Indexes A-Z -- Applications” on the Air Force Portal at https://www.my.af.mil/etims/ETIMS/ETIMS/menu/index.jsp; select the "E" category of the index and then "ETIMS", or e-mail atoms@wpafb.af.mil.)

(Approved users may access these US Army documents via the Army Publishing Directorate’s Product Map site at http://www.apd.army.mil/ProductMap.asp.)

(Alternately, users may contact their organizational Tech Manuals Distribution Office. Contractors obtain Tech Manuals through their Government Contract Monitor.)

FEDERAL AVIATION ADMINISTRATION (FAA)

Federal Aviation Regulation

FAR Part 25, Subpart H	Electrical Wiring Interconnect System (EWIS)

Advisory Circulars

AC 25-16	Electrical Fault and Fire Prevention and Protection
AC 25-26	Development of Standard Wiring Practices Documentation

AC 25-27	Development of Transport Category Airplane EWIS ICA Using an Enhanced Zonal Analysis Procedure
AC 25.1701-1	Certification of Electrical Wiring Interconnection Systems on Transport Category Airplanes
AC 43.13-1	Aircraft Inspection and Repair
AC 120-94	Aircraft Electrical Wiring Interconnection Systems Training Program
AC 120-97	Incorporation of Fuel Tank System Instructions for Continued Airworthiness into Operator Maintenance or Inspection Programs
AC 120-102	Incorporation of Electrical Wiring Interconnection Systems Instructions for Continued Airworthiness into an Operator's Maintenance Program
AC 25.1309-1A	System Design and Analysis

(Copies of these documents are available online at http://www.faa.gov.)

2.3 Non-Government publications.

The following documents form a part of this document to the extent specified herein.

SAE INTERNATIONAL

ARP4404	Aircraft Electrical Installations
ARP6216	EWIS Insulation Breakdown Testing
AS4372	Performance Requirements for Wire, Electric, Insulated Copper or Copper Alloy
AS4373	Test Methods for Insulated Electric Wire
AS5692/2	Circuit Breaker, ARC Fault - Aircraft, Trip Free, 1-20 Amp, Type I
AS50881	Wiring, Aerospace Vehicle
AS81824	Splices, Electric, Permanent, Crimp Style, Copper, Insulated, Environment Resistant
JA1011	Evaluation Criteria for Reliability-Centered Maintenance (RCM) Processes
JA1012	A Guide to the Reliability-Centered Maintenance (RCM) Standard

(Copies of these documents are available from SAE International, 400 Commonwealth Drive, Warrendale PA 15096-0001 USA; www.sae.org.)

3 DEFINITIONS

3.1 Analysis.
Analysis is the diagnostic effort that illustrates contractual requirements have been achieved. This effort may include solution of equations, performance of simulations, evaluation and interpretation of charts and reduced data, and comparisons of analytical predictions versus test data. The normal reduction of data generated during ground and flight tests is not included. This effort is usually performed by the contractor.

3.2 Branch.
A section of harness that divides off and extends to a point of termination

3.3 Bundle.
Any number of harnesses or branches routed and supported together along some distance within the aircraft

3.4 Cable.
Two or more insulated conductors, solid or stranded, contained in a common covering, or two or more insulated conductors twisted or molded together without common covering, or one insulated conductor with a metallic covering shield or outer conductor

3.5 Chafing.
The deterioration of a material through repeated relative motion between two or more components. This repeated relative motion can be between wiring system components, or a wiring system component and structures or equipment that will likely result in mechanical or electrical failure during the vehicle's specified service life.

3.6 Connector plug.
The connector containing the coupling ring or active retention device of the mating pair

3.7 Connector receptacle.
The connector containing the static retention device of the mating pair

3.8 EWIS.
Any wire, fiber optic link, wiring or fiber device, or a combination of these items (including terminations) installed in any area of the aircraft for the purpose of transmitting electrical energy, signals, or data between two or more electrical end points

3.9 Fiber optics.
A general term that describes a lightwave or optical communications system. In such a system, electrical information is converted to light energy, transmitted to another location through optical fibers, and is there converted back into electrical information.

3.10 Fireproof.
The capability of a material or component to withstand a 2000ºF flame (±150ºF) for 15 minutes minimum, while still fulfilling its designed purpose

3.11 Fire resistant.
The capability of an item (as defined in "fireproof") to perform its intended function in designated fire zone areas under heat and other abnormal conditions, as encountered in power plants and

auxiliary power unit (APU) installations, that are likely to occur at the particular location or area to withstand a 2000ºF flame (±150ºF) for 5 minutes minimum

3.12 Firewall.
A structural panel designed to prevent a hazardous quantity of air, fluid, or flame from exiting a designated fire zone and cause additional hazard to the aircraft. This structural panel permits penetration of fluid-carrying lines (fuel and hydraulics), ducts, electrical power and control cables and/or rods through the use of suitable fireproof components or fittings. The firewall and the attached components or fittings must withstand flame penetration and must not exhibit backside ignition for the required test time (15 minutes). The backside temperature should not exceed 450ºF maximum and the structural panel should have fireproof insulating material installed to limit the backside temperature.

3.13 Fire zone.
A designated area or enclosure generally considered to be within certain selected areas within engine nacelles and APU installations that can, under abnormal operating conditions, experience temperatures approaching 2000˚F. These conditions are generally the result of fuel or hydraulic line failures, heat duct failures, or engine case burn through that allows high-pressure *and* high-temperature gas to escape from the engine, and similar types of failures. The engine nacelles, APU compartment, fuel burning heaters, weapon exhaust areas, and other combustion equipment installations are some typical fire zones. Other areas may also be considered fire zone areas; e.g., wheel wells, due to heat generated from the brakes.

3.14 Flammable.
The capacity of being something (solid, liquid, or gas) to be easily ignited and burn quickly

3.15 Flammable vapor zone.
A fire protection zone on the aircraft where flammable fluid/vapor is routinely present (e.g., inside fuel tanks)

3.16 Flammable fluid leakage zone.
A fire protection zone on the aircraft where a single failure (such as a fuel leak) will introduce the presence of flammable fluid/vapor

3.17 Group.

A number of wires and/or electrical/optical cables and their terminations secured together within the structure of a bundle or harness. Groups normally contain wire and/or electrical/optical cables pertaining to a single circuit or routed to a single item of equipment.

3.18 Harness.
An assembly of any number of wires, electrical/optical cables and/or groups and their terminations designed and fabricated to allow for installation and removal as a unit. A harness may be an open harness or a protected harness.

3.19 Improbable occurrence.
An occurrence with the risk of failure shown to be less than $1x10^{-7}$ events per flying hour (FH)

3.20 Integrity.
Integrity is comprised of the essential characteristics of systems and equipment that allows for specified performance, safety, durability, reliability, and supportability to be achieved under specified operational conditions over a defined service lifetime.

3.21 Maintenance Steering Group – 3 (MSG-3) analysis.
This is a structured analysis, based on Reliability Centered Maintenance principles, that identifies appropriate preventative maintenance tasks to optimize aircraft availability versus maintenance cost. MSG-3 analysis is widely used in the commercial aviation industry.

3.22 Mean Time Between Failures (MTBF).
MTBF is a parameter that historically has been used to define the reliability of components.

3.23 Open harness.
An assembly of wires and/or electrical/optical cables that does not include an outer protective covering

3.24 Primary support.
Support provided for wiring that carries the weight of the wiring and secures it in the intended position (Also see SAE AS50881, 3.11.1.)

3.25 Protected harness.
A harness that employs some overall outer covering to provide additional mechanical protection for the wires and/or electrical/optical cables contained therein. The added protection may consist of an over-braid, tape wrap, conduit, or some other form of protection.

3.26 Redundancy.
Redundancy in design incorporates dual/multiple components or duplicates function to provide operational capability (without degradation) upon failure of a single component or function. Failure of a single component or function must be detectable (i.e., system is both fail operational and fail evident).

3.27 Secondary supports.
Supports used to secure the cabling between primary supports

3.28 Severe Wind And Moisture Prone (SWAMP) Areas.
Areas such as wheel wells, wing folds and areas near wing flaps, and areas directly exposed to prolonged weather conditions are considered SWAMP areas on aerospace vehicles.

3.29 Spot ties.
Ties other than secondary support ties used to separate a number of wires, electrical/optical cables, groups, or harnesses within a bundle

3.30 Test.
Empirical efforts performed to prove that contractual requirements have been met. Documented procedures, instrumentation, and known environmental conditions are normally applicable. Compliance or noncompliance is determined by observation, where practical, and evaluation of collected data. Most ground and flight empirical efforts associated with this procurement and acquisition qualify as tests. This effort is usually performed by the contractor.

3.31 Wire.
A single metallic conductor of solid, stranded, or tinsel construction designed to carry current in an electrical circuit but without a metallic covering, sheath, or shield. “Wire” refers to “insulated electrical wire” for the purpose of this specification.

3.32 Wiring.
Wires, electrical/optical cables, groups, harnesses and bundles, and their terminations, associated hardware, and support, installed in the vehicle. When used as a verb it is the act of fabricating and installing these items in the vehicle.

3.33 Wiring components and devices.
The accessory parts and materials used in the installation of electrical and optical wiring, such as terminals, connectors, junction boxes, conduits, clamps, insulation, and supports.

3.34 Wire segment.
A length of wire that is continuous and unbroken between its two intended points of termination. A wire segment that has been broken and then repaired is still considered to be one wire segment.

3.35 Work Unit Code (WUC) Manual.
A manual that assigns a code to each commonly performed maintenance task, thus allowing for tracking of maintenance on specific components and the recording of causes for non-mission capable time, maintenance man-hours, etc.

3.36 Acronyms.

AC	Advisory Circular
A/C	Aircraft
AFB	Airframes Bulletin
AFHA	Aircraft Level Functional Hazard Assessment
APU	Auxiliary Power Unit
ASA/SSA	Aircraft Safety Assessment/System Safety Assessment
ATSRAC	Aging Transport Systems Rulemaking Advisory Committee
BIT	Built-in-Test
CAMP	Continuous Airworthiness Maintenance Program
CCA	Common Cause Analysis
CDCCL	Critical Design Configuration Control Limitation
CPC	Corrosion Prevention Compounds
DAH	Design Approval Holder
DET	Detailed Inspection
EAPAS	Enhanced Airworthiness Program for Airplane System
ECO	Engineering Change Order
ECP	Engineering Change Proposal
EFHA	EWIS Level Functional Hazard Assessment
EWIS	Electrical Wiring Interconnect System
EZAP	Enhanced Zonal Analysis Program
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FH	Flying Hour
FHA	Functional Hazard Assessment
FM	Failure Mode
FMECA	Failure Modes Effects and Criticality Analysis

FQIS	Fuel Quantity Indicator System
GVI	General Visual Inspection
IMDS	Integrated Maintenance Data System
ICA	Instructions for Continued Airworthiness
IPB	Illustrated Parts Breakdown
JDRS	Joint Deficiency Reporting System
JEDMICS	Joint Engineering Data Management Information and Control System
JFOWG	Joint Fiber Optic Working Group
JSWAG	Joint Services Wiring Action Group
KPI	Key Performance Issue
L/HIRF	Lightning and High Intensity Radiated Field
LRU/WRA	Line Replaceable Unit/Weapons Replaceable Assembly
MRBR	Maintenance Review Board Reports
MTBF	Mean Time Between Failures
MSG	Maintenance Steering Group
NALDA	Naval Aviation Logistics Data Analysis
NAVAIR	Naval Air Systems Command
OEM	Original Equipment Manufacturer
PA	Public Address
PASA/PSSA	Preliminary Aircraft Safety Assessment/ Preliminary System Safety Assessment
PDM	Program Depot Maintenance
PHA	Preliminary Hazard Analysis
PHL	Preliminary Hazard List
PM	Program Manager
PVC	Polyvinyl Chloride
RCMA	Reliability-Centered Maintenance Analysis
REMIS	Reliability and Maintainability Information System
RF	Radio Frequency
SAE	SAE International
SHA	System Hazard Analysis
SoS	System-of-Systems
SRHA	System Requirements Hazard Analysis
SSA	System Safety Assessment
SSHA	Subsystem Hazard Analysis
STC	Supplemental Type Certificate
SWAMP	Severe Wind And Moisture Prone
TAA	Technical Airworthiness Authority
TC	Type Certificate
TCTO	Time Compliance Technical Order
TM	Technical Manual

TO	Technical Order
TR	Thrust Reverser
USAF	United States Air Force
WUC	Work Unit Code
XL-ETFE	Cross-linked Ethylene-Tetrafluoroethylene
ZIP	Zonal Inspection Program

4. CORE PROCESS TASKS.

The core process tasks in this section should be tailored to specific program office needs and may include all or a combination of these tasks as necessary to assess EWIS condition, support an approach to service life extension, and establish and sustain continued airworthiness. A large portion of the information in Appendices A through H was derived from FAA ACs. These documents reference approval authorities as a Design Approval Holder (DAH), or as Type Certificate (TC) or Supplemental Type Certificate (STC) holders. The military airworthiness authority is typically identified as the System Program Manager or Technical Airworthiness Authority (TAA). For this document, the designation will be the TAA when the DAH, or TC or STC holder is called out in a FAA AC.

4.1 Core Process Task One.

Document overall EWIS and identify critical circuit paths and functions (AS50881, AC 25.1701-1, AC 25-27A, and AC 25.1309-1A). (See appendix B for additional guidance.)

4.1.1 Identify EWIS components and materials and all power and signal paths.

4.1.2 Document wiring configuration and circuit schematics and functions.

4.1.3 Document physical wire routing throughout the aircraft.

4.1.4 Conduct an aircraft functional hazard assessment consisting of a system safety and common causes assessment; and EWIS failure modes, effects, and criticality analysis (FMECA) (AC 25.1701-1).

4.1.5 Document EWIS components and characteristics such as installation and separation.

4.1.6 Identify catastrophic failure modes and mechanisms in critical EWIS components.

4.1.7 Identify physical failures of the EWIS that can cause damage to co-located EWIS or surrounding systems, structural elements, or injury to personnel.

4.1.8 Develop a Critical Design Configuration Control Limitation (CDCCL) for fuel system EWIS components.

4.1.9 Examine physical separation of Fuel Quantity Indicator System (FQIS) circuits from high-power electrical circuits. This would be based on drawings.

4.2 Core Process Task Two.
Collect and analyze EWIS failure and maintenance data (See appendix C for guidance when utilizing a process to conduct a detailed analysis.)

4.2.1 Document how the aircraft EWIS failure and maintenance data is collected and analyzed.

4.2.2 Review and assess mishap and maintenance databases and applicable Airworthiness Directives.

4.2.3 Interview maintenance and engineering support staff.

4.2.4 Use data mining approaches to examine maintenance and failure data for wiring chafing, broken wires, arcing, burned wiring, electrical fires, electrical insulation dielectric failure, and corrosion. Search electrical bonding, fiber optics, connectors, relays, switches, circuit breakers, distribution panels, and other EWIS components that may exist in the system under review.

4.2.5 Review findings, maintenance actions, discrepancies, and repairs accomplished as part of mandatory or voluntary inspections.

4.2.6 Organize data by zone/station, probability, and criticality of failure.

4.3 Core Process Task Three.
Conduct an on aircraft physical and electrical inspection and document overall condition of the aircraft EWIS. Results of this task may be used to identify and target critical problem areas for EWIS initiatives or further evaluation. (See appendix D for guidance.)

4.3.1 Use findings from Tasks One and Two based on the failure criticality to select zones for inspection. Use available wiring design and installation documents SAE AS50881 or applicable platform-specific contractual design/installation documents for additional guidance.

4.3.2 Develop inspection checklist for the selected zones.

4.3.3 Conduct a physical inspection and document overall condition of aircraft electrical system using guidelines established in MIL-HDBK-522.

4.3.4 Specifically examine wiring for exposed conductors, cracked or deteriorated insulation, loss of insulation mechanical properties, excessive splices, presence of contamination/corrosion, or insulation discoloration due to overheating conditions.

4.3.5 Examine circuit breakers, distribution panels, and other conductive path components for corrosion, thermal damage, and electrical degradation.

4.3.6 Large or complex areas should be divided into manageable size. Emphasize Severe Wind And Moisture Prone (SWAMP) and high-maintenance areas.

4.3.7 Prepare and document with photos findings from the physical inspection. Discrepancies that may impact aircraft safety should be identified for immediate action.

4.4 Core Process Task Four.

Conduct a comprehensive materials/aging analysis of wiring and electrical components removed from the aircraft based on information gathered in earlier tasks. (See appendix E for additional guidance.)

4.4.1 Use findings from Tasks One, Two, and Three for selection of EWIS components for removal.

4.4.2 Conduct a lab or visual inspection to document condition of components and follow with a detailed materials examination which may include electrical mechanical, chemical, and/or destructive aging analysis of selected EWIS components.

4.4.2.1 Wiring insulation and conductor integrity

4.4.2.2 Protective harness materials

4.4.2.3 Shield and ground terminations

4.4.2.4 Connector contact integrity and shield effectiveness

4.4.2.5 Circuit breaker contact integrity and the trip curve

4.4.2.6 Relay contact integrity and actuation performance

4.4.2.7 Switch contact integrity and actuation performance

4.4.2.8 Electrical distribution panel components

4.4.2.9 Terminal boards, ground studs, and connector back shells

4.4.2.10 Compare condition of components with new (unused) components

4.4.3 Apply aging assessment techniques and aging/degradation models to determine remaining life of EWIS components, if available or established.

4.4.4 Review the results of the comprehensive analysis performed on the electrical components removed from the aircraft.

4.5 Core Process Task Five.

Analyze and provide an overall risk and life assessment of the aircraft electrical system using the findings from the first four tasks. (See appendix F for additional guidance.)

4.5.1 Apply algorithms or models that provide an EWIS risk assessment based on failure histories, failure modes and mechanisms, materials properties, and environmental and maintenance conditions.

4.5.2 Address criticality of the wiring system and its impact on aircraft safety, reliability, and availability.

4.5.3 Review safety assessment process in MIL-STD-882 and AC 25.1701-1.

4.5.4 Consider electrical fires, reported hazards, system reliability, and availability.

4.5.5 Analyze and provide an overall EWIS risk and life assessment using collected data (Tasks One through Four).

4.5.6 Prepare a report on the aircraft EWIS risk and life assessment. Where possible, the report should identify the risk at the device, system, and aircraft level.

4.6 Core Process Task Six.

Apply Overall Analysis toward an action plan (i.e., no changes, implement continuous inspections, partial or total replacement, implement new technologies). (See appendix G for additional guidance.)

4.6.1 Use the collected data from Tasks One through Five to provide recommendations to mitigate risk through inspection, replacement, or upgrade of wiring system components, etc.

4.6.2 Recommend scheduled inspections over system life.

4.6.3 Recommend installation of new technology to improve long-term performance and reduced cost.

4.6.4 Update maintenance manuals to include the following for EWIS fuel tank system components: mandatory replacement times, inspection intervals, related inspection instruction/procedures, and Critical Design Configuration Control limitation for fuel system components.

4.6.5 Prepare a report that details the recommendations on how to mitigate identified risks. The report should include recommended updates/changes to maintenance and inspection processes.

4.7 Core ProcessTask Seven.

Tailor and apply Core Tasks One through Six iteratively as required to reassess EWIS and to ensure desired outcomes have been achieved and maintained. The tailoring and iterative application should also consider changes in platform-specific program direction, and changes to operational requirements such as service life, mission, etc. (See appendix H for additional guidance.)

5 MANAGEMENT METHODS

5.1 General.

The EWIS and ultimately the aircraft safety, reliability, and availability can be improved significantly through performance of the seven Core Process Tasks outlined in this handbook and implementation of an action plan developed from the EWIS assessment; use of timely, effective application of training; accurate attention to detail in the upkeep of technical data; and periodic review and adjustment of the EWIS assessment.

5.2 Policies and guidance.

EWIS policies and guidance must be aligned with the goals of the organizational mission; the primary purpose being maintaining aircraft airworthiness and meeting required performance, availability, and cost.

5.2.1 Quality.

Quality becomes part of the way business is conducted rather than merely an organizational department when a culture of excellence is established. The Quality Control (or uniformed Service-specific equivalent) unit must have an overarching goal of the never-ending improvement of the maintenance output. Where there are quality shortfalls, a mechanism must exist to ensure training needs are recognized and action taken to bridge the quality gap.

5.3 Training.

Training courses for electronics/electrical/avionics technicians can be found in the Advanced Wire Maintenance course (J4AMP30000 A48A) created by the Air Force Technical Training Center. Additional training resources for primary EWIS technicians as well as the secondary users can be found in the FAA training program outlined in AC 120-94. Technicians for military aircraft based on a commercial aircraft (commonly referred to as a commercial derivative aircraft) should review the FAA training program outlined in AC 120-94. See appendix A for a more detailed discussion on training.

5.4 Technical data.

All technical data, whether Illustrated Parts Breakdowns (IPB), Wiring Diagrams, or Fault Isolation Manuals, must be technically accurate. The safety notations and warnings/cautions, along with the technical content, must be continuously upgraded as the information changes. Inaccurate Wiring Diagrams or Fault Isolation Manuals often lead to misdiagnoses of the causes of system failure and waste resources on parts unnecessarily removed and sent to repair facilities.

A frequent cause of faulty technical data occurs when technical manuals (especially wiring diagrams) are not changed when the system is modified or upgraded. Every weapon system modification or upgrade must receive a corresponding technical data change based on the Engineering Change Order / Proposal (ECO) / ECP) when the Time Compliance Technical Order (TCTO) or Airframes Bulletin (AFB) is issued.

Another technical data issue involves the current maintenance data collection processes and systems. Inadequate EWIS Work Unit Codes (WUCs) often lead to misattribution of EWIS failures to aircraft components where failures are first exhibited, such as Avionics systems (e.g., display indications). EWIS maintenance WUCs are limited and difficult to define effectively. Current systems and processes fail to capture fully and attribute failures to the EWIS. This results in an underestimation of the extent and impact of EWIS problems. As such, when developing the inspection process and reviewing any maintenance data analysis results, it is imperative that close collaboration is maintained between end users (operators/maintainers), engineering, logistics, and aircraft original equipment manufacturers (OEMs).

6 FAILURE MODES AND LESSONS LEARNED.

The failure modes of EWIS components and subsystems follow certain patterns during the failure process as discovered through past EWIS analysis. When EWIS components or subsystems' life exceeds the designed lifespan, they must be replaced to mitigate the risk of loss. Precise analysis is necessary to discover exactly where the "hotspots" of failure clusters are so they can be "selectively replaced". Many of these failure modes (FMs) can be found in MIL-HDBK-522. EWIS components are considered electromechanical devices which make them susceptible to moving surfaces, wear out, and general wear and tear during maintenance actions.

6.1 Wires.

Wiring is the most critical of all EWIS components and most susceptible to damage by various forms of mechanical, electrical, and chemical stresses. The majority of aircraft wiring insulation in military service is of a thin-walled construction, and is thus susceptible to various forms of damage such as:

1. Primary insulation:
   a. Chafing, fraying, peeling, cuts, cracking, thermal damage, crazing, embrittlement, softening, cold flow, unraveling/layer separation, recession, thinning, and other forms of insulation layer deformation/separation/breaches
   b. Discoloration/charring from stress exposure or aging
   c. Loss of dielectric or insulation resistance
2. Primary conductor and shield braid:
   a. Broken or damaged strands
   b. Corrosion
   c. Red plague type corrosion typically associated with silverplated copper conductors
   d. Diameter reduction
   e. Discoloration from internal or external stress exposure
   f. Short between primary conductor and the shield
3. Cable jacket:

   Chafing fraying, cuts, cracking, thermal damage, crazing, softening, cold flow, unraveling/layer separation, recession, thinning, and other forms of insulation layer deformation/separation/breaches.

The probability of failure and deterioration increases in SWAMP areas or areas in high vibration, high temperature or severe temperature fluctuations, high moisture, fluid contamination or areas with fluid leaks, or a high-maintenance area. Further guidance on the evaluation and inspection of wiring can be found in MIL-HDBK-522. Degraded or failed wiring should be removed and analyzed to determine failure cause so the proper corrective action can be taken.

6.1.1 Splices.

The Joint Services Manual TO 1-1A-14 (see table I) defines a "splice" as the, "connection of two or more conductors or cables to provide good mechanical strength as well as good connectivity". The primary failure mode of a splice is high resistance due to failure of the interconnection between the splice barrel and wire. This may be a result of overheating due to improper crimping, corrosion, or aging. Only environmentally-sealed, mechanically-crimped splices may be used in accordance with the requirements of the airframe manufacturer's standard wiring practices, or SAE AS81824 or equivalent specification, particularly in un-pressurized and SWAMP areas.The possibility of fluid contamination in any installation needs to be always considered. Use of splices should follow SAE AS50881 guidelines. Further guidance on the evaluation and inspection of splices can be found in MIL-HDBK-522.

6.1.2 Cables.

SAE AS50881 defines "electrical cable" as, "Two or more insulated conductors, solid or stranded, contained in a common covering, or two or more insulated conductors twisted or molded together without common covering, or one insulated conductor with a metallic covering shield or outer conductor". The primary failure modes of a cable are the same as for wires. A common failure mode is a short between shield and primary conductor. Controlled impedance cable (e.g., twisted pair, coaxial cable, etc.) should be accessed for impedance characteristics such as impedance, velocity of propagation, and Voltage Standing Wave Ratio.

6.1.3 Fiber optics.

The Joint Services Manual TO 1-1A-14 defines "fiber optics" as a, "General term describing a lightwave or optical communications system. In such a system, electrical information is converted to light energy, transmitted to another location through optical fibers, and is there converted back into electrical information." Failure modes are similar as those for wires but also include degradation of the internal reflective surface. Fiber optic systems are also susceptible to damage and/or contamination at mating surfaces. The Joint Fiber Optic Working Group (JFOWG) is the group of technical experts which provides subject matter expertise in this focus area.

6.2 Connectors.

Many connector configurations exist and most aircraft use the circular MIL-DTL-38999 connector type. Like wire, connectors are also susceptible to damage caused by various forms of exposure. The connector is susceptible to:

1. External damage caused by corrosion and mechanical stresses;
2. Internal damage caused in part by excessive handling in areas of frequent maintenance activity;
3. Microscopic ("fretting") corrosion, worn pins and sockets;
4. Degradation caused by exposure to petroleum-based fluids, moisture, salt water and high humidity, and cleaning and deicing solutions; and
5. Excessive heat in high temperature zones such as engine and auxiliary power unit (APU) bays. The probability of failure and deterioration increases in SWAMP areas.

Connector failures are typically associated with intermittent or "Cannot Duplicate" type issues. Further guidance on the evaluation and inspection of connectors can be found in MIL-HDBK-522. Degraded or failed connectors should be removed and analyzed to determine failure cause so the proper corrective action can be taken.

When connector damage is discovered, the connectors and/or pins and sockets may need to be replaced to restore the system to its original state. Attempt to use environmentally-sealed connectors that meet MIL-DLT-38999 or another defense specification for connectors if connector replacement is required due to damage or system upgrades. Connection-related failures can sometimes be discovered prior to complete system functional failure through reliability analysis on intermittent issues or high "Cannot Duplicate" rates, as well as through aircraft preventative maintenance.

Consider use of approved corrosion prevention compounds (CPCs) such as MIL-L-87177 and MIL-C-81309 type III for electronic and electrical applications on external connector surfaces in high vibration areas and SWAMP areas. The correct CPC type needs to be selected for electronic and electrical applications. Follow application guidelines in TO 01-1A-14 and in accordance with General Services Wiring Manuals and weapon system-specific technical manuals. Minimize CPC overspray and keep material from contacting wire insulation and other insulation products since some CPCs can degrade insulation properties. Also be aware that CPCs can collect dust, sand, and other debris and may not be suitable for certain environments. CPC s may not be appliedto any composite/non-metallic connectors, or any connectors containing fiber optics.

6.3 Relays.

Like connectors, relays are also susceptible to damage caused by various forms of exposure, as well as “cycle wear”. The relay is susceptible to arcing damage, wear-out of the switching mechanism, or degradation and corrosion from various fluids and heat exposure. Relays typically have a limited service life which can be shortened significantly if the relay contacts are underrated or near or at their design rating for the intended application. Periodically stuck or jammed contacts or switching mechanisms are evidence of wear-out or premature failure. Discrepant parts should be removed and analyzed to determine the failure cause so the proper corrective or design action can be taken. In some cases, the wiring entering the relay can be the source of a failure. General degradation caused by exposure, resulting in an increased probability of failure caused by corrosion and deterioration, increases in SWAMP areas.

6.4 Switches.

Like relays, switches are also susceptible to damage caused by various forms of exposure; as well as “cycle wear”. The switch is susceptible to arcing damage, wear-out of the switching mechanism, or degradation and corrosion from various fluids and heat exposure. Switches typically have a limited service life which can be shortened significantly if the contacts are underrated or near or at their design rating for the intended application.

Switches that fail to actuate or complete electrical connection should be removed and analyzed to determine the failure cause so the proper corrective action can be taken. In some cases, wire entering the switch can be the source of a failure. General degradation caused by exposure, resulting in an increased probability of failure caused by corrosion and deterioration, increases in environmental exposure in SWAMP areas.

6.5 Circuit breakers.

Circuit breakers are critical devices since they protect the EWIS from over-current conditions and can disable critical circuits when they trip prematurely. Most circuit breakers used on legacy aircraft are thermal mechanical devices that use a calibrated bimetallic element to trip the device when current exceeds the trip curve characteristic. Like switches, circuit breakers are susceptible to damage caused by various forms of exposure, as well as “cycle wear”. The breaker is susceptible to arcing damage, wear-out of the trip mechanism, or degradation and corrosion from various fluids and heat exposure.

Breakers typically have a limited life which can be shortened significantly if the electrical contacts are underrated or marginal for the intended application or if the device is used as switch. Some common failure modes are: the inability to actuate the device or breakers which require a high reset force (typically from corrosion), premature tripping, overheating due to high contact resistance, and the worst-case failure mode—failure to trip when there is an over-current event. Breakers should be analyzed and replaced to determine the cause of the failure whenever any of these conditions exist. It is possible to measure contact resistance and use the value to assess the overall condition of the breaker. Probability of failure increases in SWAMP areas.

Further guidance on the evaluation and inspection of circuit breakers can be found in MIL-HDBK-522. Specially note circuit breaker inspection and cycling guidelines in the handbook. Damaged or degraded circuit breakers will need to be replaced to restore system reliability. Upgrade of the system with SAE AS5692/2 Arc Fault Circuit Breakers is another method to reduce the risk of arc track wire damage (common occurrence for, but not limited to, polyimide tape wrapped wire construction, MIL-DTL-81381).

6.6 Pressure seals.

A pressure seal is an area where a wire bundle passes through a pressure bulkhead using a bulkhead connector or potted seal fitting. Examples would be between a pressurized and unpressurized bay or where one side of a connector is in a fuel compartment and the other side is in a dry bay area. Pressure seals may also be used when a wire bundle passes through a firewall and other openings in the structure. This is typically a hermetic connector with glass-to-metal seal in the connector pin feed-through; the feed through may also use an elastomeric grommet cork and bottle-type seal.

6.7 Design and installation.

The primary military aircraft EWIS design and installation document is SAE AS50881. This document has current best practices as recommended by military and industry EWIS subject matter experts. It is contractually enforced on some systems while on other systems it is used as a guidance standard by both military program offices and OEMs. Deviation from this document should require extensive engineering analysis. Programs are encouraged to apply the latest version of SAE AS50881 to their EWIS design and installation since it will include the latest safety and design practice improvements as determined by the military and aerospace industry. Programs do need to review changes for cost impact. Programs should also use SAE ARP4404 for additional detailed guidance on the installation and maintenance of EWIS components. This handbook has valuable lessons learned on all types of EWIS components.

6.8 Maintenance.

Wiring maintenance is typically based on aircraft-specific Technical Manuals prepared by the platform OEM or the Joint Service General Wiring, Connector, and Fiber Optic Cabling Technical Manuals which appear in table I. Table I also shows the Technical Manual designations for the U.S. Navy, U.S. Air Force, and U.S. Army, which are now harmonized documents. These manuals are DoD Service-coordinated documents and are regularly updated with the latest wiring practices and repair technologies and should be used only when they do not conflict with OEM-prepared Technical Manuals, higher-order documents, or contractual requirements. Note that Service-specific requirements are occasionally called out in these documents. The System Program Manager should regularly review the latest versions of these Technical Manuals. The System Program Manager should encourage his/her maintenance organizations to use the most current versions of these documents and participate in the Joint Service Wiring Action Group (JSWAG), which coordinates changes and updates these Technical Manuals (e-mail: jswag@navy.mil, Website: http://www.navair.navy.mil/jswag).

TABLE I. Joint Services Manual cross-reference.

MANUAL TOPIC	NAVY	AIR FORCE	ARMY
General Wiring	01-1A-505-1	1-1A-14	1-1500-323-24-1
Circular Connectors	01-1A-505-2	1-1A-14-2	1-1500-323-24-2
Rectangular Connectors	01-1A-505-3	1-1A-14-3	1-1500-323-24-3
Fiber Optic Cabling	01-1A-505-4	1-1A-14-4	1-1500-323-24-4

6.9 Other electrical and mechanical systems and interfaces that can impact the EWIS.

The following systems and interfaces can affect the operational safety, suitability, and effectiveness of the EWIS and should be identified, checked, and monitored throughout the lifecycle of the aircraft.

6.9.1 Electrical interfaces.

Electrical interfaces are often critical to emergency situations. Examples of critical interfaces include, but are not limited to, communications channels between computers, between sensors and computers, and between computers and actuators. Special attention should also be paid to circuits that engage flight modes. Landing rollout mode interfaces, such as anti-skid braking control, should also be taken into consideration.

6.9.2 Flight and throttle controls.

While obvious problems with flight controls are routinely reported by aircrews, many systems degrade slowly. Bearings slowly develop friction and pawls slowly wear down. What a pilot of an aging aircraft considers to be normal may in fact be a sign of impending failure. Control sticks and yokes or throttle quadrants are used hundreds of times every flight and need to be carefully examined. Mechanical drive components often operate with an on-condition maintenance philosophy, but exist outside normal maintenance procedures and are not checked by Built-in-Test (BIT) functions. Throttle control systems must be reviewed, even on multi-engine aircraft. Engine out scenarios that result in loss of redundant electrical and hydraulic systems can be more critical in aging aircraft than they are in a new air vehicle. As components age, wear or deterioration in one system component is often masked by a secondary system that is taking the extra load. For example, a transmission with dual input stages may be badly worn on one end but still be functioning because the other end is carrying the entire load.

6.9.3 Interfacing systems, hardware, and software disciplines subsystems.

These systems and subsystems often operate in an integrated fashion with many aircraft configuration items that are outside the engineering responsibilities and boundaries of subsystems engineering. These areas will require special consideration on how to manage the overall life cycle safety of the complete system as many subsystems interface with and rely on electrical systems, egress systems, power systems, structural elements, materials engineering, and avionics.

6.9.4 Systems without BIT tests (partially tested devices).

Many actuators cannot be fully tested on the aircraft. Built-in-Test can test only those parts of a system that are “electrically” monitored and active on the ground. Many other parts of the system may go untested. An example would be an asymmetry control brake that works in both an electrically activated and over speed mode. A BIT test could check the “electrical” activation circuit, but it cannot tell if the brake actually set. An on-aircraft test could verify the brake set in electrical mode, but may not test the over speed braking mode. Untested modes need to be evaluated for deterioration, and tested modes must be relevant to the particular failure mode being investigated.

7 DETAILED REQUIREMENTS DEVELOPMENT

7.1 Appendix A.

Appendix A describes elements for development of an enhanced EWIS training program.

7.2 Appendix B.

Appendix B describes the data necessary to document the overall EWIS and identify critical circuit paths and functions.

7.3 Appendix C.

Appendix C describes the analysis of existing maintenance data and data mining to disclose EWIS impacts.

7.4 Appendix D.

Appendix D describes elements of physical inspection programs of all EWIS installed on aircraft.

7.5 Appendix E.

Appendix E describes the processes and sampling techniques associated with EWIS component assessment.

7.6 Appendix F.

Appendix F describes tasks for the development of an EWIS risk assessment.

7.7 Appendix G.

Appendix G describes tasks for the development of a risk mitigation action plan.

7.8 Appendix H.

Appendix H describes the application and tailoring of the risk assessment action plan and lessons learned through the aircraft active duty life cycle.

8 NOTES

8.1 Intended use.

The intent of EWIS design is to build a system with the same longevity as the airframe structure per FAA AC 25.1701 (d) (8) (a). However, the current age of some legacy weapon systems significantly exceed the original service life requirements. Moreover, the calculated longevity of these legacy EWIS systems are not uniform throughout the aircraft, but are averaged. Some EWIS system components have a much shorter lifespan than the average, and some components' lifespan are much longer than average. EWIS exposure to environmental stresses or personnel performing maintenance will limit EWIS life. Alternately, EWIS in areas infrequently accessed by maintenance personnel or in pressurized or protected environments may increase EWIS life. This handbook outlines a process to capture the available data required to establish and execute an effective EWIS Integrity Program and for service life extension. It should be tailored based upon aircraft specific circumstances (such as maintenance data availability, financial constraints, new platform versus legacy, planned service life, current aircraft age, current or expected mission requirements, etc.)

Execution of the EWIS program as outlined in this handbook will assist in identification and justification of resources required to maintain EWIS integrity and ultimately aircraft airworthiness. Strategies to develop an EWIS integrity action plan will vary from platform to platform considering aircraft specific circumstances and may include full aircraft rewiring, targeted rewiring, training initiatives, automated wiring test, scheduled inspections, periodic data monitoring, improved chafe protection, and more. These processes may also be modified as required to provide metrics on the effectiveness of the implemented EWIS integrity strategy (e.g., maintenance data trending/analysis, follow-on hazard assessment, etc.). A properly-applied EWIS Integrity Program will ensure a reliable and airworthy EWIS which will translate into lower aircraft life cycle costs and improved mission availability.

8.2 Subject term (key word) listing.

Airworthiness
Bundle
Chafing
Cable
Circuit breaker
Clamp
Connector
Failure
Firewall
Fiber optics
Harness
Hazard, fault
Maintainability
Maintenance
Mean Time Between Failure
Receptacle
Redundancy
Reliability
Socket
Splice
Switch
System Safety
Tie
Wire
Work Unit Code

APPENDIX A

ELECTRICAL WIRING INTERCONNECTION SYSTEMS (EWIS) MINIMAL INITIAL TRAINING PROGRAM CONTENT

A.1 SCOPE.

This appendix provides guidance for developing an enhanced EWIS training program. The training is divided into 1) Operators, 2) Maintainers, and 3) Support personnel. Additional training information can be found in AC 120-94.

A.2 AC 120-94, APPENDICES A, B, AND C (REMOTE LOCATION).

J4AMP30000 A48A - Advanced Wire Maintenance Course

Description:

Provides advanced training on wire maintenance procedures as they apply to any aircraft platform utilizing TO 1-1A-14

Training includes: identification of wire maintenance practices, principles, procedures, inspection, wire repair and build-up for various wire types and cabling to include associated connectors, and basic soldering practices

Course is 80 hrs. / 10 academic days

Entry Prerequisites: Completion of Basic Soldering Course or soldering certification/ sign-off through work-center training documents

Maximum class size is 6.

A.3 COURSE OBJECTIVES.

General Procedures

a. Use TO 1-1A-14 and Work Packages 002 00, 003 00, and 026 00 to identify wire maintenance procedures and concepts, with a minimum accuracy of 80 percent.
b. Use TO 1-1A-14 and Work Package 004 00 to identify wire characteristics and techniques, with a minimum accuracy of 80 percent.
c. Use TO 1-1A-14 and Work Package 006 00 to identify Radio Frequency (RF) characteristics, with a minimum accuracy of 80 percent.
d. Use TO 1-1A-14 and Work Package 009 00 to identify wire and cable stripping procedures, with a minimum accuracy of 80 percent.
e. Use TO 1-1A-14 and Work Package 010 00 to identify wire harness installation characteristics, with a minimum accuracy of 80 percent.
f. Use TO 1-1A-14 and Work Packages 011 00 and 011 01 to identify wire harness repair procedures, with a minimum accuracy of 80 percent.
g. Use TO 1-1A-14 and Work Package 013 00 to identify contacts, terminals, splices, and caps characteristics, with a minimum accuracy of 80 percent.
h. Use TO 1-1A-14 and Work Package 014 00 to identify wire and cable splicing and repair characteristics, with a minimum accuracy of 80 percent.

i. Use TO 1-1A-14 and Work Package 021 00 to identify RF connector characteristics, with a minimum accuracy of 80 percent.
j. Use TO 1-1A-14 and Work Package 024 00 to identify connector accessories, with a minimum accuracy of 80 percent.
k. Use TO 1-1A-14 and Work Package 025 00 to identify characteristics of Potting and Sealing Connectors, and Electrical Cable Assemblies and Electrical components, with a minimum accuracy of 80 percent.
l. Use TO 1-1A-14 and Work Package 027 00 to identify Terminal Junction System characteristics, with a minimum accuracy of 80 percent.

A.4 INSPECTION ANALYSIS.

Use TO 1-1A-14 and Work Package 004 01 to identify wiring deficiencies, with a minimum accuracy of 80 percent.

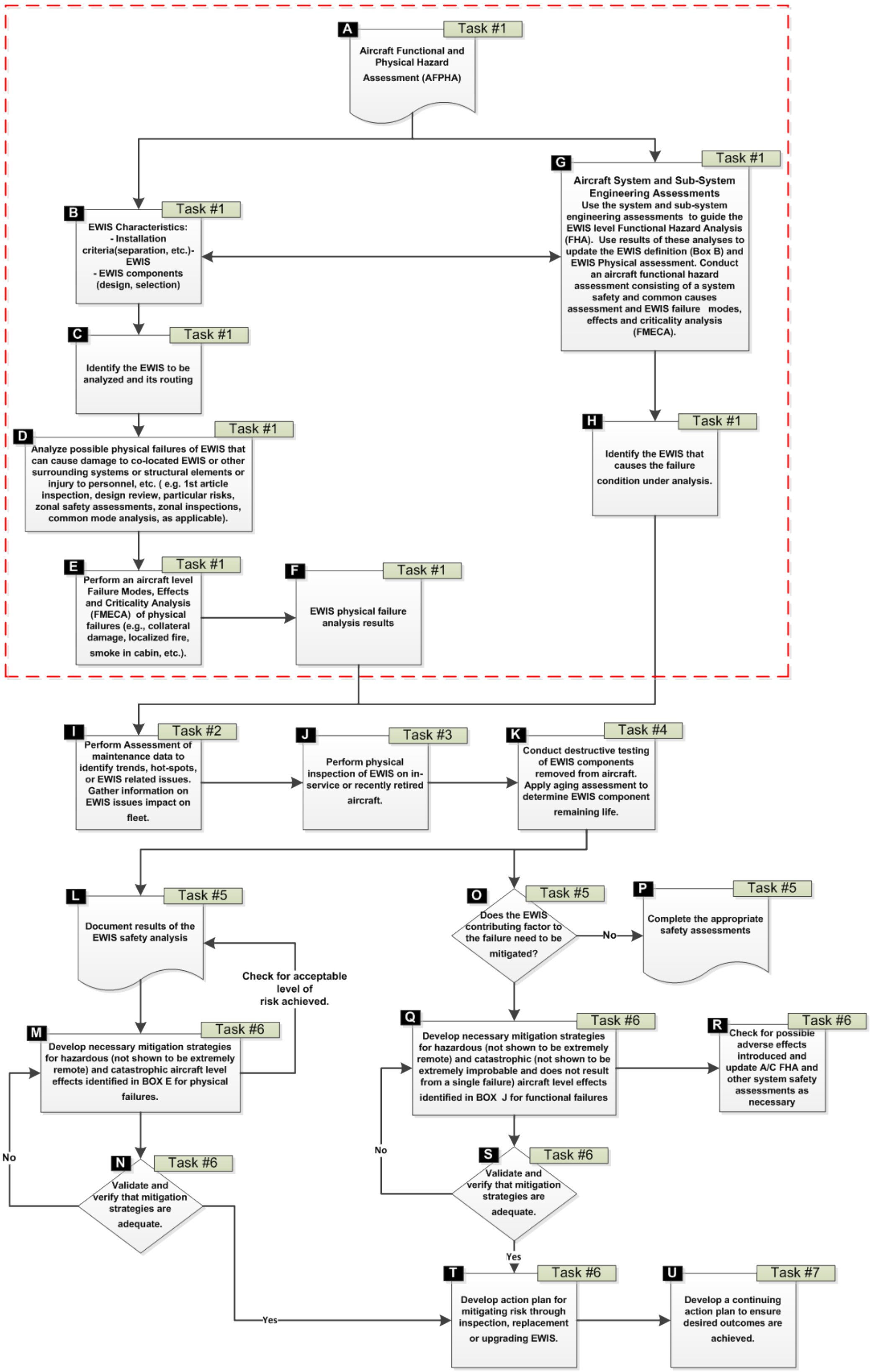
APPENDIX B

EWIS TASK ONE – EWIS DOCUMENTATION

B.1 SCOPE.

The task objective is to generate the data necessary to document overall EWIS and identify critical circuit paths and functions. The task analyses focus on gathering data combined with a preliminary aircraft impact assessment of EWIS device failures.

A simplified process flow for the EWIS risk assessment is shown on figure B-1. This flow chart shows how the data gathered during this phase is combined and utilized through the other tasks performed in the EWIS risk assessment. The tasks performed in Task One are those within the highlighted region.



NOTE: The red-dashed boxed area covers hazard assessment performed in Task #1.

FIGURE B-1. Process flow for risk assessment.

B.2 APPLICABLE DOCUMENTS

B.2.1 General

The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

B.2.2 Government documents

B.2.3 Non-Government publications.

The following documents form a part of this document to the extent specified herein.

SAE INTERNATIONAL

ARP4754 Guidelines for Development of Civil Aircraft and Systems

(Copies of this document are available from SAE International, 400 Commonwealth Drive, Warrendale PA 15096-0001 USA; www.sae.org.)

B.3 Aircraft Functional and Physical Hazard Assessment (AFPHA).

Box A: Aircraft Functional and Physical Hazard Assessment (figure B-1). The AFPHA includes both an aircraft functional aircraft hazard assessement and a physical analysis on actual on-aircraft EWIS systems. It assumes that electrical wires are carrying power, signal, or information data. Failure of EWIS under these circumstances may lead to aircraft system degradation effects. The functional hazard assessment is made up of the system safety assessments that apply scientific and engineering principles, criteria, and techniques to identify and document hazards at the aircraft and EWIS levels. These analyses are described in more detail in MIL-STD-882 and AC 25.1309-1A. The physical hazard analysis identifies physical failures of the EWIS that can cause damage to co-located EWIS or surrounding systems, structural elements, or injury to personnel. The two assessments combine to comprise the AFPHA.

B.3.1 Aircraft zone breakdown.

If the aircraft does not already have established aircraft zones, these must be identified first. Wherever possible, the definition of zones should follow a consistent method varied only to accommodate particular design and constructional differences. For the purposes of this assessment, the aircraft should be divided into environmental zones. Define the zones, wherever possible, by actual physical boundaries such as wing spars, major bulkheads, cabin floor, control surface boundaries, skin, etc., and include access provisions for each zone.

B.3.2 Zone definition.

The environmental consideration for each zone should include the following:

a. Temperature,
b. Vibration,
c. Chemicals,
d. Humidity, and
e. Contamination.

Zones should have a consistent environmental condition profile. A zone should be subdivided if major variations in environmental conditions occur within the zone. An example of this is inside the pressure vessel cabin of a transport aircraft. The wiring below the floor boards is likely exposed to contamination from spilled fluids whereas the wiring along the walls to ceiling is unlikely exposed to the same.

Table B-I provides an example set of breakpoints to be used to partition the aircraft into environmental zones. Additions to this breakdown can be made as necessary to best describe the platform under analysis.

TABLE B-I. Example breakpoints for zone environmental conditions[1].

DATA FIELD	LEVEL 1	LEVEL 2	LEVEL 3
Temperature	Pressure and temperature controlled area	Operation temperature less than 100C; pressure may be either controlled or uncontrolled.	Operation temperature over 100˚C
Vibration	Low vibration (e.g., main fuselage)	Moderate vibration	High vibration (e.g., engines)
Chemicals (toilet fluids, de-icing fluid, etc.)	Isolated area with rare exposure to chemicals	Exposure to chemical may occur but is uncommon.	Regular exposure to chemicals
Humidity	Isolated area with rare exposure to humidity	Exposure to humidity may occur but is limited or uncommon.	Direct exposure to atmosphere (e.g., wheel wells)
Contamination	No contamination likely in these areas	Exposure to contamination may occur but is uncommon.	Highly likely to be exposed to contamination during the course of operations
Other	Any other factor that may impact the longevity of the wiring		

[1] Subsequent EWIS maintenance procedures, developed from this evaluation (Task #6), are designed based on a maintenance zone size. Zone size will be roughly limited to a 6-foot cube.

B.4 EWIS identification.

Box B: EWIS characteristics (figure B-1). Use the aircraft-level FHA results (Box A) to identify EWIS installation criteria and definitions of component characteristics. Results of Box B are fed into the PSSA and SSA of Box G.

The wiring information should be gathered from a "representative aircraft." The representative aircraft is the configuration of each model series aircraft that incorporates all variations of EWIS used in production on that series aircraft. For example, a particular aircraft model may have both a cargo and transport variation. Dependent on the variation, the resultant EWIS failure hazard assessment must account for any differences between the two versions. The placement of galleys, lavatories, and equipment may impact the routing and furthermore the functional hazard assessment. The resultant EWIS assessment must reflect any such differences.

Sufficient data on the electrical systems is necessary for the failure hazard assessment process. This includes wires (power, signal, and fiber optic), connectors, splices, relays, circuit breakers, power buses, connectors, grounding points and equipment that is associated with the delivery of electrical power or signal.

B.4.1 Wire information.

The information for wiring may come from wiring lists, wiring diagrams, or a parts list. This information should (at a minimum) include:

a. Wire ID,
b. Pin to Pin (from-to data),
c. Gauge,
d. System,
e. Specification, and
f. Length.

An example of the wire data can be seen in table B-II.

TABLE B-II. Example of gathered wire data.

Wire ID	System	From	Pin	To	Pin	Wire Spec	Gauge	Length (in)	DRW #
1JC110 - \1JC110	Environmental controls	JC110	1	\1JC110	1	22759/34	22	60	8721001
*BPZ004 - *BPZ004	Environmental controls	PZ004	*B	*BPZ004	*B	22759/34	22	48	8721001
20JA505 - \20JA505	Environmental controls	JA505	20	\20JA505	20	22759/34	22	155	8721001
2JC110 - *HJA001	Environmental controls	JC110	2	JA001	*H	22759/34	22	120	8721001

B.4.2 Circuit protection device information.

This includes any sort of device that is used for circuit protection such as thermal circuit breakers, arc fault interrupters, fuses, or solid state protection devices. For these devices, the collected information should include the following:

a. Circuit protection device type,
b. Reference Designator,
c. Current rating,
d. Specification,
e. Power supply (e.g., 115V or 28VDC), and
f. Location (zone).

An example of the circuit protection data is shown in table B-III.

TABLE B-III. Example of gathered circuit protection data.

Ref Des	Type	Rating (A)	Power Supply	Spec	Location	System
P13	Circuit Breaker	5	28VDC	Generic Thermal CB	Flight Deck	Hydraulic Low Pressure Warning
P8	Circuit Breaker	5	28VDC	Generic Thermal CB	Flight Deck	Hydraulic Oil Quantity Indicator
P11-2	Circuit Breaker	5	28VDC	Generic Thermal CB	Flight Deck	Boom Position Indicator
P14	Circuit Breaker	5	28VDC	Generic Thermal CB	Flight Deck	Battery Circuit Breaker Panel

B.4.3 Relays or switching device information.

Switching devices that change the power on a given circuit are included in the EWIS data gathering. For the switching devices, the information gathered should include the following:

a. Switching device type,
b. Reference Designator,
c. Specification,
d. Configuration (SPDT, DPDT, etc.),
e. Location (zone), and
f. System.

An example of the switching data is shown in table B-IV.

TABLE B-IV. Example of gathered switching data.

Ref Des	Type	Config	Location	System
S197	Switch	DPDT	Flight Deck	Engine
S198	Switch	DPDT	Flight Deck	Flight Control
S3-1	Switch	SPDT	Flight Deck	Engine
M288	Relay	SPDT	Flight Deck	Engine

B.4.4 Connectors.

Connectors are used to attach wiring harnesses to LRUs/WRAs or connect through zones. The information gathered on connectors should include:

a. Reference designator,
b. Specification,
c. Zone, and
d. Systems routed in connector.

An example of the connector data is shown in table B-V.

TABLE B-V. Example of gathered connector data.

Ref Des	Spec	Location	Systems
D51-80	M13.5	Flight Deck	Hydraulic Low Pressure Warning, Hydraulic Oil Quantity Indicator
D51-81	M13.5	Flight Deck	Engine Oil, Bleed Air
D51-82	M13.5	Flight Deck	Fire Protection, Landing Gear

B.4.5 LRUs/WRAs and connected devices.

While the examination of wiring stops at the connection for LRUs/WRAs, function and performance of electrical devices are also included in the EWIS failure hazard assessment. All electrical devices must be catalogued and failure consequence assessed (Section B.3). The information gathered should include:

a. Reference designator,
b. Attached connectors,
c. System,
d. Function, and
e. Location (zone).

B.4.6 Wire harness information.

Box C: EWIS Routing (figure B-1): Identify the EWIS that is to be analyzed and its routing. Ensure that the EWIS component qualification satisfies the design requirements and that components are selected, installed, and used according to their qualification characteristics and the aircraft constraints linked to their location.

Use available information (digital mockup, physical mockup, aircraft data, and historical data) to perform inspections and analyses to validate that design and installation criteria are adequate to the zone/function, including considerations of multi-systems impact. Such inspections and analyses may include a first article inspection, design review, particular risk assessment, zonal safety assessment, zonal inspection, and common mode analysis, as applicable. Use such assessments and inspections to ascertain whether design and installation criteria were correctly applied. Special consideration should be given to known problem areas identified by service history and historical data (areas of arcing, smoke, loose clamps, chafing, arc tracking, interference with other systems, wires and cables that are required to regularly flex, such as those in doors and hatches, etc.). An in-depth historical data evaluation is performed in Task Two.

Among the more difficult information to gather for the wire assessment is the wiring harness information. Basic wire harness routing information, such as zone, can be gathered from installation drawings. Additional information, such as proximity to equipment and hydraulic/fuel lines may require examination of a representative aircraft. If multiple models are considered in the assessment, the routing on each of these aircraft should be identified.

The harness routing information should include the following:

a. Termination points,
b. Harness protection (if any),
c. Nearby harnesses and separation distances,
d. Nearby hydraulic/fuel lines and separation distances, and
e. Zone(s) in which the harness is routed.

An example of this information is shown in table B-VI.

TABLE B-VI. Example of gathered harness data.

Harness Ref Des	Harness Protection	Nearby Harnesses	Nearby lines	Zone
74A753209-9CAB	Open Harness	74A753210-9CAC	Hydraulic Return Line	Flight Deck
74A753210-9CAC	Open Harness	74A753209-9CAB	Hydraulic Return Line	Flight Deck
74A753227-9CGA	Nomex	74A753209-9CAB	Fuel line	RH trailing wing
74A753228-9CGA	Open Harness	None	None	Under Floor, Cabin
74A753237-9BVA	Open Harness	None	None	Under Floor, Cabin

The routing within each of these harnesses should also be gathered. This includes the wire routing through each harness and requires the division of harnesses into logical sections where no branching occurs called bundle sections.

The information associated with the bundles sections should include:

a. Harness identifier or ref des,
b. Section identifier,
c. Length,
d. Protection, and
e. Termination points.

The wire routing can be identified when the harnesses are divided into bundle sections. The information for the wire sections should include the wire ref des and the bundle section identifier.

B.5 EWIS separation identification.
The EWIS routing information through the aircraft must be gathered to provide data on systems co-located within harnesses, harnesses in close proximity, and nearby hydraulic/fuel system equipment. Often this information cannot be gathered from wiring diagrams alone. Wiring harnesses may have many branches, and the physical/functional composition can change for each branch. The routing of the wires within the harnesses is critical to electrical arc damage analysis.

Examination of the installation diagrams requires identification of both the wiring harness routing and the termination points (connectors, devices, terminal blocks, etc.). Once the routing and termination points are identified, the harnesses can then be manually examined and their locations will be described (e.g., harness W334, zone, door 9).

1. Provides location information to easily correlate harnesses with hot spot environments in the aircraft (see section C.6.2).
2. Significantly increases the accuracy of severity of wire failure analyses. This improved accuracy is due to additional information on collocated systems (not to be conducted in Task One).
3. Improves the electrical arc damage potential projection as the constituent wires can be identified and the available power can be better determined. This also increases the validity of arc damage projections to nearby objects (not to be conducted in Task One).

As each aircraft model has different components, and different systems routed in different locations, this assessment will need to be done for at least each aircraft model and may be necessary for each aircraft depending on build standard.

B.6 EWIS Physical Failure Impact.

Box D: EWIS Physical Failure Impact (figure B-1). Regardless of probability, a single arcing failure should be assumed for any power-carrying wire. The intensity and consequence of the arc and its mitigation should be substantiated. Special considerations should be given to cases where new (previously unused) material or technologies are used. This requires that the selection of wires must take into account known characteristics in relation to each installation and application to minimize the risk of wire damage, including any arc tracking phenomena.

The potential arc damage at any location in a wire bundle is dependent on a number of factors, which include (but are not limited to): distance from the generator, number of power wires in the harness, and wire insulation type. Additional information can be gathered from the harness examination, as it provides the ability to perform collocation analyses effectively.

An example of the physical damage assessment is shown in table B-VII. In this example, the safe physical separation from each harness bundle section is assessed as the branching within the harness can impact the safe physical damage distance. In this particular application, three separation distances were identified: hydraulic lines, open harnesses, and protected harnesses.

TABLE B-VII. Example physical failure analysis on selected bundle sections.

Harness Ref Des	Harness Protection	Bundle Section	Power Classification	Safe Separation from Hydraulic line (inch)	Safe Separation from Open Harness (inch)	Safe Separation from Nomex Protected Harness (inch)
74A753209-9CAB	Open Harness	A	High	2	3	2.5
74A753209-9CAB	Open Harness	B	High	2	3	2.5
74A753209-9CAB	Open Harness	C	Medium	1	1.5	1
74A753227-9CGA	Nomex	A	Low (signal)	N/A	N/A	N/A
74A753227-9CGA	Nomex	B	Low (signal)	N/A	N/A	N/A

B.6.1 Aircraft-Level Physical Failure.

Box E: EWIS Physical Failure Aircraft-Level Impact (figure B-1). The impact analysis performed in Box D should be examined at the aircraft level. The impacts of these failures and their criticality should be assessed as they correspond to the FMECA and the failure severity table.

B.6.1.1 Common Cause Assessment.

Only single common cause events or failures need to be addressed during the physical failure analysis as described in this handbook. Multiple common cause events or failures need not be addressed.

In relation to physical effects, it should be assumed that wires are carrying electrical energy and that, in the case of an EWIS failure, this energy may result in hazardous or catastrophic effects directly or when combined with other factors; e.g., fuel, oxygen, hydraulic fluid, or damage by passenger/crew. These failures may result in fire, smoke, emission of toxic gases, damage to co-located systems and structural elements, and/or injury to personnel. This analysis considers all EWIS from all systems (autopilot, auto throttle, Public Address (PA) system, etc.) regardless of the system criticality.

The physical damage evaluations completed in Section B.6 should be used to determine the impact on nearby systems and components. An example of this assessment is shown in table B-VIII.

TABLE B-VIII. Example assessment of arc damage on nearby system components.

Harness Ref Des	Bundle Section	Impacted Target	Safe Separation to Target (in)	Current Separation Distance (in)	Potential Impact
74A753209-9CAB	A	74A753209-9CAB	2.5	3	N/A
74A753209-9CAB	B	Hydraulic Return Line	2	1	Physical standoffs separate the harness from the hydraulic return line. Arc damage modeling suggests potential for hydraulic line breach in case of arc failure.
74A753209-9CAB	C	Hydraulic Return Line	2	1.5	Physical standoffs separate the harness from the hydraulic return line. Arc damage modeling suggests potential for hydraulic line breach in case of arc failure.
74A753227-9CGA	A	N/A	N/A	N/A	Contains only signal wires. No arc possible.

B.6.1.2 Catastrophic physical failure assessment.

No ignition source may be present at each point in the fuel tank or fuel tank system where catastrophic failure could occur due to ignition of fuel or vapors. This must be verified via:

1. Determination of the locations subject to highest temperatures and allowing a safe margin below the lowest expected autoignition temperature of the fuel in the fuel tanks;
2. Demonstration that no temperature at each place inside each fuel tank, where fuel ignition is possible, will exceed a safe operating temperature. This must be verified under all probable operating, failure, and malfunction conditions of each component whose operation, failure, or malfunction could increase the temperature inside the tank; and
3. Demonstration that an ignition source could not result from each single failure, from each single failure in combination with each latent failure condition not shown to be extremely remote, and from all combinations of failures not shown to be extremely improbable. The effects of manufacturing variability, aging, wear, corrosion, and likely damage must be considered.

B.6.1.3 EWIS physical failure analysis results.

Box F: Physical failure analysis documentation (figure B-1). From the EWIS physical failure analysis, document:

a. Physical failures addressed;
b. Effects of those physical failures; and
c. Viable mitigation strategies developed (the validity of the mitigation strategies evaluated in Task Six).

The physical failures, both direct and common causes, should be documented and, if necessary, possible mitigation strategies for unsatisfactory results. The selection of the mitigation technique used is determined in Task Six.

B.7 Aircraft system and subsystem engineering assessments.
Box G: Use the aircraft system and sub-system engineering assessments to guide the EWIS-Level Functional Hazard Assessment (EFHA). These analyses are performed to satisfy requirements such that the occurrence of any failure condition which would prevent the continued safe flight and landing of the aircraft is extremely improbable. Conduct an aircraft-level functional hazard assessment (AFHA) that consists of a system safety and common cause assessment and EWIS FMECA. Use the results of these analyses to update the EWIS definition (Box B) and EWIS physical assessment. Once the EFHA is completed feedback these results into higher level subsystem and aircraft engineering assessments.

The system safety engineering assessments are defined in MIL-STD-882 and SAE ARP4754.

A summary of the analyses provided in MIL-STD-882 are listed below:

a. Preliminary Hazard List (PHL), Task 201
b. Preliminary Hazard Analysis (PHA), Task 202
c. System Requirements Hazard Analysis (SRHA), Task 203
d. Subsystem Hazard Analysis (SSHA), Task 204
e. System Hazard Analysis (SHA), Task 205
f. Functional Hazard Analysis (FHA) of an individual system or subsystem, Task 208
g. System-of-Systems (SoS) to identify unique SoS hazards, Task 209.

A summary of the engineering assessments provided in SAE ARP4754 used to develop the risk assessment and identify hazards per FAA guidelines for EWIS are:

a. Functional Hazard Assessment (FHA) (also referred to as the AFHA in this document), examines aircraft and system functions to identify potential functional failures and classifies the hazards associated with specific failure conditions.
b. Preliminary Aircraft Safety Assessment/Preliminary System Safety Assessment (PASA/PSSA) establishes the aircraft or specific system or item safety requirements and provide a preliminary indication that the anticipated aircraft or system architectures can meet safety requirements.
c. Aircraft Safety Assessment/System Safety Assessment (ASA/SSA) collects, analyzes, and documents verification that the aircraft and systems, as implemented, meet the safety requirements established by the PASA and the PSSA.
d. Common Cause Analysis (CCA) establishes and verifies physical and functional separation, isolation, and independence requirements between systems and items and verifies that these requirements have been met.

Use the severity categories taken from the MIL-STD-882 (table B-IX) to examine the EWIS devices identified in the previous sections. These devices must be associated with a failure consequence.

TABLE B-IX. Severity Categories[1].

DESCRIPTION	SEVERITY CATEGORY (CAT)	MISHAP RESULT CRITERIA
Catastrophic	1	Could result in one or more of the following: death, permanent total disability, irreversible significant environmental impact, or monetary loss equal to or exceeding $10M
Critical	2	Could result in one or more of the following: permanent partial disability, injuries or occupational illness that may result in hospitalization of at least three personnel, reversible significant environmental impact, or monetary loss equal to or exceeding $1M but less than $10M
Marginal	3	Could result in one or more of the following: injury or occupational illness resulting in one or more lost work day(s), reversible moderate environmental impact, or monetary loss equal to or exceeding $100K but less than $1M
Negligible	4	Could result in one or more of the following: injury or occupational illness not resulting in a lost work day, minimal environmental impact, or monetary loss less than $100K

[1](Source: MIL-STD-882E, Table I)

At this stage in the assessment, the failure consequence should focus on direct EWIS component loss. Examples of failures to consider include:

a. Loss of connector,
b. Loss of relay or switch, and
c. Loss of a wire harness or individual section of a wire harness.

An example of a system device evaluation can be seen on figure B-2. A CAT 1 component has been identified (red-outlined box) and four devices feed information or power into the component (devices 1, 2, 3 and 6). Each device connected to the CAT 1 component are examined to determine if any other devices are necessary to ensure the reliable operation of the CAT 1 component (e.g., identify if the source data for Device 6 comes from Device 4 and 5).

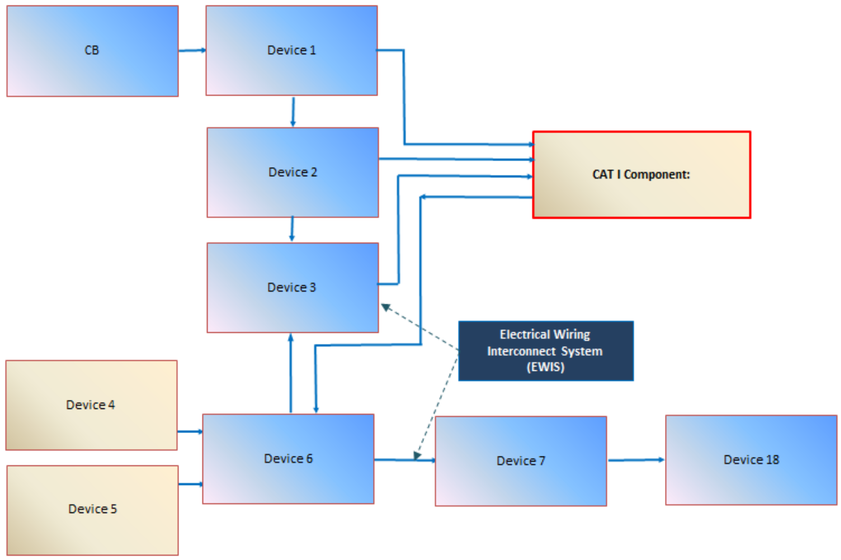


FIGURE B-2. Example system diagram for CAT 1 component.

B.7.1 Identify catastrophic failure modes for critical EWIS components.

Box H: Hazardous and catastrophic failure conditions (figure B-1): Use the analyses in Box G to determine if the EWIS associated with the system under analysis can contribute (in whole or in part) to the failure condition under study. The assessment should examine common cause failure for redundant systems routed in the same harness or in close proximity to one another.

Determine whether the EWIS failure requires mitigation. Any EWIS failures which requires mitigation should be identified and included in the Task One report. Strategies for mitigation will be developed and verified in Task Six. If no mitigation is necessary, complete the appropriate safety assessment.

Document the results of the functional failure assessment. The results of the assessment will be used to direct the inspections performed (Task Three), component selection for degradation assessment (Task Four), EWIS risk assessment (Task Five), and mitigation strategies (Task Six).

APPENDIX C

EWIS TASK TWO – DATA ANALYSIS

C.1 SCOPE.

This appendix describes the analysis of existing maintenance data and data mining to disclose EWIS impacts and is based upon information provided in MIL-HDBK-683, Statistical Process Control (SPC) Implementation and Evaluation Aid.

C.2 OVERVIEW.

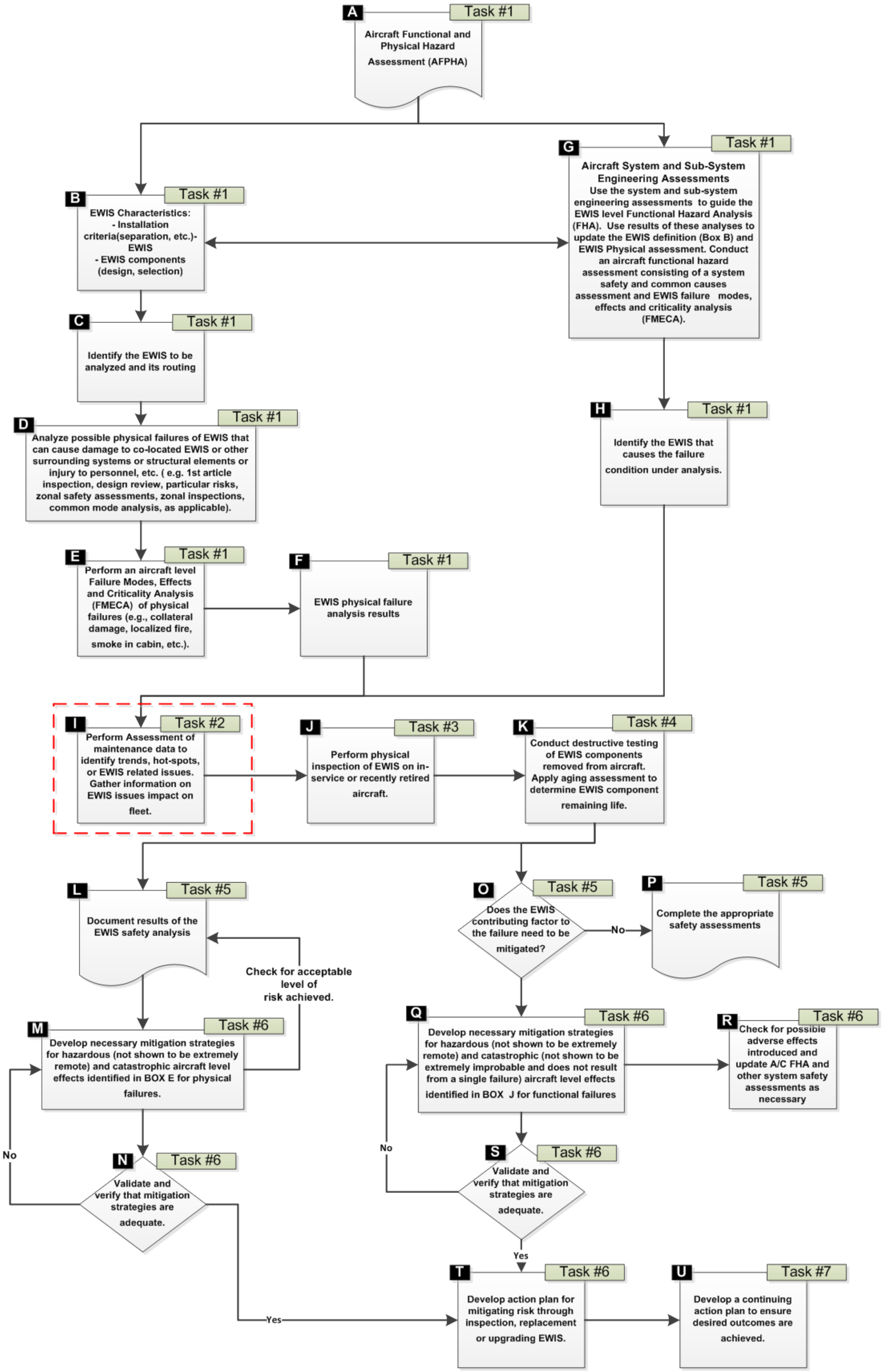
The overall risk assessment can benefit from the analysis of existing maintenance data. This data mining provides insights into the aircraft condition and how the aircraft is maintained. Through analysis, this data can be used to identify:

a. Hot spots (systems that are main drivers of maintenance actions),
b. The scale of EWIS repairs,
c. Areas for focus during the inspection process (Task Three), and
d. The overall risk assessment process.

There are multiple ways to review and analyze the data; thus, it is possible to misinterpret the data and arrive at incorrect conclusions. Techniques and analyses described here are generalized and are independent of the maintenance data source.

The reliability of EWIS component historical data is uncertain. While important information and previously unidentified issues may be identified through the data assessment process, the historical data analysis conclusions should be reported with caution and not overstate the aircraft condition. This information is one part of an overall EWIS risk assessment process and must be combined with more information to determine the overall impact on the aircraft.

The dependencies of Task Two efforts are shown on figure C-1.



NOTE: The red-dashed boxed area includes the data analysis performed in Task Two.

FIGURE C-1. Process flow for risk assessment.

C.3 GENERAL.

The first step is to determine EWIS condition and extent of problems (or Root Cause). Solution formulation is normally a more straightforward process if all problems are identified. The following analytical methodologies have been used to identify conditions and/or performance gaps.

Different analytical methods are available for use; each one is valid for a given situation or environment. A thorough understanding of the methods listed below is essential for the analyst to use statistical and cost analysis accurately to diagnose EWIS-related issues.

C.3.1 Visual observation.

Visual observation is valid under certain conditions; however, it depends largely on the observer's experience, knowledge, and degree of access. This type of observation provides limited information and may not be useful or meaningful for complex situations. This method is limited as a stand-alone analysis and should be considered useful when combined with the other methods.

C.3.2 Comparative analysis.

Comparative analysis may be performed statistically or visually and involves comparing two or more like processes or items to identify variations or differences. Though a viable stand-alone method, it is normally used in conjunction with other methods.

C.3.3 Statistical analysis.

Statistical analysis is the methodical study of data used to reveal facts, correlations, and trends about data. It is useful in conjunction with comparative and visual analysis.

C.3.4 Analysis process.

The analysis process is the methodical conversion of data into information for managerial decision-making and control. It amalgamates the three previous methods into a single, coherent analytical process. This combination makes it the most robust of these problem-solving processes.

C.4 Data mining process.

Though there is no one best way to mine data, there are some "best practices" available. However, a standard, basic process is recommended for congruence between projects. The data mining process will vary based on the way the project is conducted.

Data is usually downloaded from the Reliability and Maintability Information System (REMIS), G081 (Maintenance Data collection system for U.S. Air Force Mobility Aircraft), Integrated Maintenance Data System (IMDS), DECKPLATE, Joint Deficiency Reporting System (JDRS), and/or the Air Force or Naval Safety Center data into a program that allows data analysis and filtering.

Use of particular measures are encouraged to maintain an accurate and reliable product, such as system data being prepared (or "scrubbed"), then separated into units based on WUC.

C.4.1 Field, Depot, and Engineering Surveys.

These surveys address issues concerning EWIS components (e.g., connectors) and subsystems (e.g., WUC 23000-engines) as well as related issues such as management, Technical Manuals, and training. The questionnaires are directed at all personnel involved with the EWIS sustainment process and should be completed at all levels of the logistics organization. For example, questions concerning power plant maintenance (WUC 23000) would be directed to everyone involved in flight line maintenance. All Bases with the related airframes and EWIS systems would be selected to participate in the survey.

Different questions would be sent to the depot facilities as they have a different type of maintenance environment geared primarily toward preventative and heavy maintenance.

System program engineers, logistics personnel, and systems safety personnel would receive questions concerning requests for assistance and various issues which require their resolution.

C.4.2 Goals for filtering of data.

The goals of the data analysis are:

a. Identify where EWIS issues exist in the fleet;
b. Determine the size of EWIS-related issues; and
c. Provide insight into how EWIS failures impact aircraft systems electrically and physically and how they relate to the risk assessment process.

C.4.3 Maintenance databases.

Maintenance and service databases are filled with entries from maintenance personnel. Historically, in the USAF, these databases were primarily designed to track part usage and manage inventory. As a side benefit, the databases can provide useful engineering data. While there is guidance provided to fleet maintainers to use common terminology in these databases, there are often misspellings, incorrect term usage, improper system identification, and multiple entries for the same issue.

Data entry errors can cause a simple keyword search to produce incomplete and/or invalid results and lead to the incorrect conclusions. A brief list of keyword terms is included in C.4.5.

C.4.4 Identify available data.

Maintenance actions are recorded in fleet-specific databases. Database systems are continually updated and enhanced since they are integral to managing aircraft operationally. The USAF and USN have developed new data management systems which allow organizations to query aircraft platform maintenance data. The USAF uses the IMDS and the USN uses DECKPLATE, which accesses the Naval Aviation Logistics Data Analysis (NALDA) system. Examples of specific databases include REMIS, G081, JDRS, and the Air Force Safety Automated System. These databases store information on aircraft maintenance actions using categories such as the WUC, a narrative with a brief problem description, or a corrective action description.

Unfortunately, many records have the wrong WUC assigned and the problem and correction action descriptions are poorly written due to misspellings, generalizations, and shorthand notation. Information mining of these databases often requires an exhaustive combination of keyword searches and ultimately a subject matter expert to read and interpret each maintenance record manually. This last action introduces subjectivity and can lead to more erroneous conclusions.

C.4.5 Keyword search.
The maintenance data can be acquired manually or automatically. If performed manually, all components of the maintenance entry or SIB entry should be reviewed for wire-related data. If performed automatically, a search algorithm will need to be developed. The algorithm will need to be verified manually for 95 percent accuracy as a minimum.

The algorithm will not disseminate the difference between what is intended and what is meant. For example, for a search of corrosion issues, the words "rot" and "rust" would be included in the search word bank as both are corrosion related. However, the search algorithm will also pull out any maintenance actions with the word "rotary" or "thrust" if the search is not generated properly and results will be skewed.

Looking through "wire glasses" will also yield inaccurate results; specifically, using words with double meanings; e.g., the word "wire". While wire is related to wiring issues, “safety wire” on a fastener (bolt or screw) also results from that search. Safety wire maintenance actions are common for a variety of components and may have no relation to the EWIS.

An effective search algorithm would be to use “wir” or “cabl” and not “safety wir” to capture EWIS wiring records. This would locate records with “wire”, “wiring”, “wired”, “cable”, and “cables”, and eliminate safety wire (wiring) records.

Simple human narratives input errors are another issue that directly affects the results; e.g., misspelled words and trade names. For example, a search was done for maintenance-related activities related to polyimide wire. The search returned zero results. Thirty results were returned when the search was repeated with the trade name, “Kapton®”. Over 150 results were returned when the search was repeated with (improper spelling), “Capton”.

Given the data condition within these databases, it is unlikely that all EWIS data can be identified unless an extensive manual effort is performed. Thus, the goal should be to achieve greater than 95 percent. This will not identify all of the actions performed on the EWIS, but will give enough insight for risk assessment purposes and support recommendations made in Task Six.

The list provided in table C-I is not all inclusive and should be supplemented by interviews with fleet maintainers. Fleet-specific terminology should be added to the keyword search.

TABLE C-I. Sample keywords for EWIS maintenance search.

“wir”	Arc	Spark	“apton”	Chaff
Tefzel (®)	tefsel	Connector	Relay	CB
Circuit breaker	Fuse	Terminal	Pin	Socket
Short	Crimp	Splice	Sleeve	Bundle
Harness	Clamp	Grommet	Conductor	Insulation
Button	Switch	Optic	Fiber	

If the data analysis is focused on all EWIS problems during the life of the aircraft, then no date ranges are necessary. However, if date ranges are necessary, this filter on the data should be included in the query criteria.

C.4.6 Keyword supplement.

As stated above, the keyword list is not all inclusive. Each aircraft has a specific set of terms and shorthand when associated maintenance data is entered. This information can be gathered from aircraft maintenance personnel via direct communication or via questionnaire.

An example of a simplified questionnaire can be found on figure C-6. It is suggested that this questionnaire be expanded and modified to best match the maintenance processes for the aircraft. After review and modification, the questionnaire should be provided to multiple aircraft technicians.

C.4.7 Data selection.

When querying the data system, a large number of data fields are available and this can be overwhelming from an analysis perspective. The data fields returned from the query can be reduced to a subset. It is recommended that, at a minimum, the following fields be selected when the analysis is performed:

a. Dates fields (date created, updated, closed, etc.),
b. Unique ID (this is the unique identifier for all maintenance records),
c. WUC,
d. Narrative,
e. System and/or subsystem,
f. Problem description,
g. Corrective action, and
h. Location.

Other fields that may be of use include: flight hours, scheduled/unscheduled maintenance, component model, and stage of operation. Note: It is easier to hide or remove data fields from a query than to add them later.

C.5 Data review.

Once the keywords have been selected and the desired data identified, run the query and store the results. An example set of results is shown in table C-II. The results are returned in a tabular form with each record on an individual line.

TABLE C-II. Example database keyword search result.

MDS	WUC	JCN	WDC	HMAL	ACFT	Discrepancy	AT	Corrective Action	MH	DATE
XXXX	XXZKD	011402041	F	255	6600008304	F/E INTERPHONE CORDS HAS FEEDBACK INOP	R	R2 STOW SWITCH	2	200105
XXXX	XXZKD	011402046	F	255	6600008304	LEFT WINGTIP AFT POSITION LIGHT OUT	R	R2 STOW SWITCH	2	200105
XXXX	XXZKD	011442166	F	255	6600008304	(X) #4 ENGINE T/R NOT LOCK LIGHT & PRESSURE LIGHT ON WITH T/R IN STOW POSITION	R	R2 STOW SWITCH THRUST REVERSER SYSTEM	2	200105

Given maintenance systems are regularly updated, it is recommended the original data be stored for further reference and the filter/review process be documented. This allows for direct traceability through the process and, if necessary, identification of possible analysis errors.

A two-tier approach is recommended to assess the entries. The first tier, performed by a junior engineer or data analyst with some familiarity of the aircraft or maintenance reports, examines each item in the data, reads the details, and tags the entries. The second tier, performed by a senior engineer or senior technician, reviews the results and makes determinations on items that are unclear.

C.5.1 Tier #1 data review.
The evaluation of the maintenance data requires manual data review. The manual record examination process should separate the records into one of three categories:

1. The record does not involve an EWIS component, or it was indirectly related (e.g., hydraulic failure caused damage to wires); or
2. The record clearly is associated with EWIS items; or
3. It cannot be deciphered whether the record is an EWIS-related event, or insufficient information was provided.

The results should be reviewed regularly to ensure the records are being accurately partitioned. This process will be able to identify 90 to 95 percent of the items, with the remaining 5 to 10 percent marked as “Unknown”.

In addition to sorting, EWIS-related items should be examined for correct WUC assignment, component type, and any other fields that may be useful in the data analysis when the maintenance actions are reviewed.

Notes for Maintenance Data review:

1. Do not delete any data. If data is not applicable, then it should be filtered out, or a column should be added to identify the information as “Not Applicable”.
2. Do not overwrite original data. Again, this is for traceability of the data. If the report is associated with the wrong WUC, then add a new column “Correct WUC” and apply the correct code.
3. Generate a list of keywords during the data examination to be included in another query on the maintenance data. Once compiled, rerun the report and merge the data. Repeat as necessary.

C.5.2 Tier #2 data review.
The Tier #2 assessment is performed by a senior engineer or technician to review the items marked as ‘Unknown’. These ‘Unknown’ entries from tier 1 are to be broken into either an EWIS related issue or non-EWIS issue. At the completion of this work, the data is ready for analysis.

C.6 Data analysis.
Data analysis begins after the data has been gathered, sorted, and cleaned up. There are multiple methods for analyzing the data, and some are presented here. These methods are intended to provide insight into the EWIS related maintenance actions that are performed on the fleet.

C.6.1 Analysis techniques.

Pareto analysis: By concentrating on 20 percent of the factors (the top drivers or the biggest problems), 80 percent of the issues will be resolved.

Use scatter diagrams to correlate data. Scatter diagrams are plots of two variables used to show the relationships between the two variables; whether they are positive or negative. For example, when trying to determine the relationship between environmental exposure and connector corrosion; a Scatter Diagram will show a positive correlation between environmental exposure and connector corrosion.

Use cause and effect (“fishbone”) diagrams to narrow causes. When relating a Key Performance Issue (KPI) to its potential causes, a powerful method is to develop a Cause and Effect Diagram, also known as a “Fishbone” Diagram. The main performance issue (or “gap”) is labeled as the fish’s head, the major categories as structural bones, and the likely specific causes as ribs. The analysis identifies the major categories of potential problem causes.

Perform trend analysis. This is merely determining the direction and/or magnitude of a trend (increasing or decreasing, strong or weak). A time-series chart can also be considered a trend measurement tool. When measuring trends on EWIS systems, various metrics such as sortie rate must be calculated and factored in when determining failure and/or cost trends.

Identify “hot spots” and/or provide solutions. The last stage of EWIS analysis is the identification of “hot spots” or failure clusters. These are areas of consistent weakness characterizes by high levels of maintenance and/or operational traffic, or excessive environmental exposure.

C.6.2 Partitioning of data.

In addition to the direct analysis of the data, other mechanisms for reviewing the data include:

1. Hot spot analysis partitioned by system, subsystem, location, zone, device type;
2. Number of maintenance actions that are allocated to the wrong WUC; and
3. If the fleet consists of multiple versions, it may be advantageous to partition the data by model. This can help identify potential issues that are experienced by a subgroup within the fleet.

C.6.3 Data fitting.

The data may also be normalized. This process helps to account for increased operations tempo or an overall increase in maintenance actions. Normalization can be based on the total number of sorties flown, hours of flight, number of total maintenance actions, or total maintenance man hours.

C.6.4 Examples.

The following are examples of Pareto analysis performed on actual maintenance data. This analysis was conducted in multiple parts (this is dependent on the desired level of analysis). Figure C-2 through figure C-4 show a progression, starting with a review of EWIS maintenance actions on all systems, followed by progressively reviewing the top contributing factors on each level of the analysis.

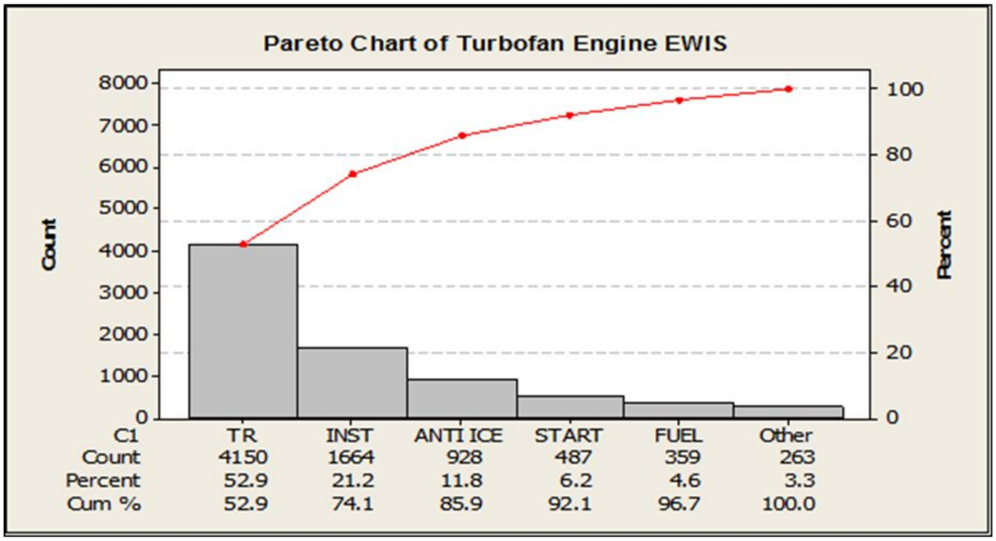


FIGURE C-2. Example of Pareto analysis of turbofan EWIS maintenance issues.

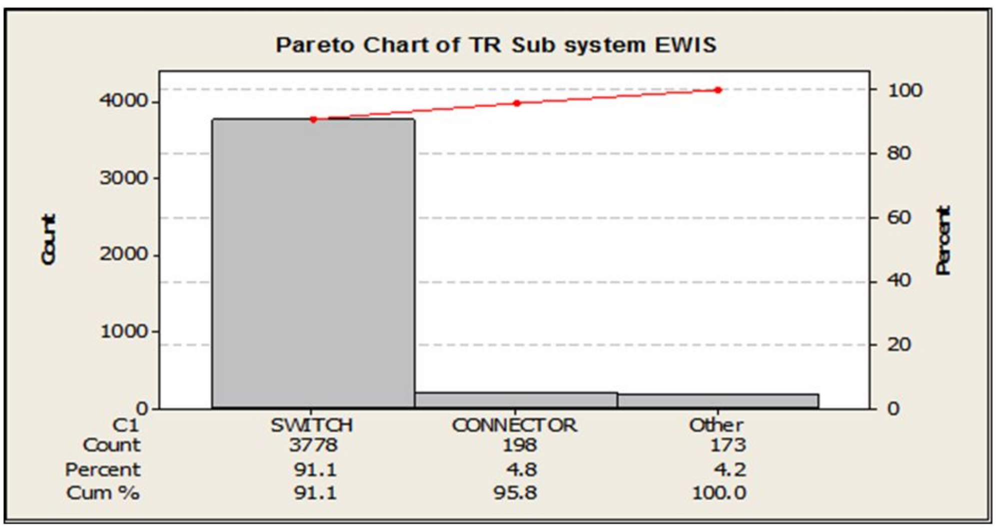


FIGURE C-3. Example Pareto analysis of TR subsystem maintenance actions.

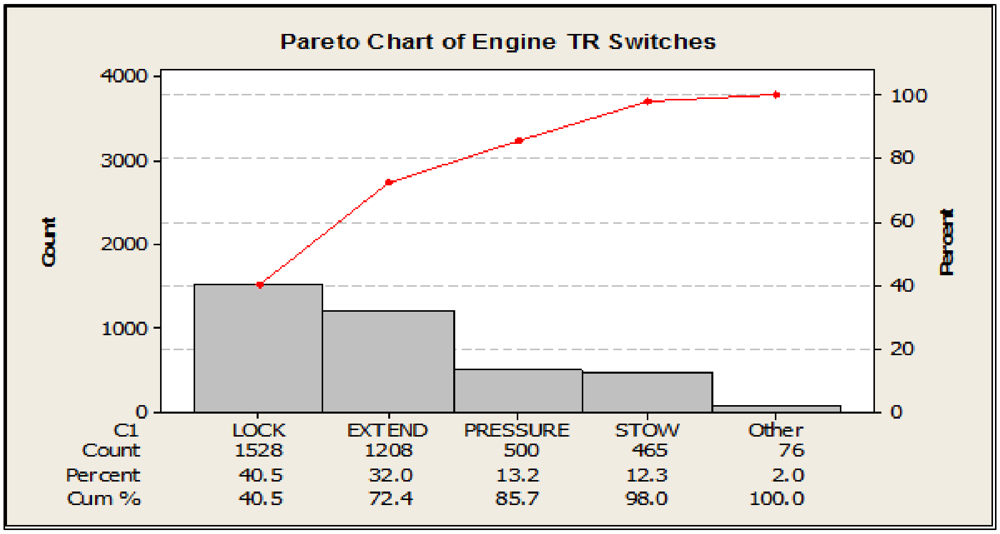


FIGURE C-4. Example Pareto analysis of engine TR switch maintenance actions.

Another method similarly identifies this issue by data partitioning. In the bar graph seen on figure C-5, the EWIS-related failures are partitioned by system and then by device type. Evidence shows the thrust reverse system switches are a significant aircraft EWIS maintenance actions contributor.

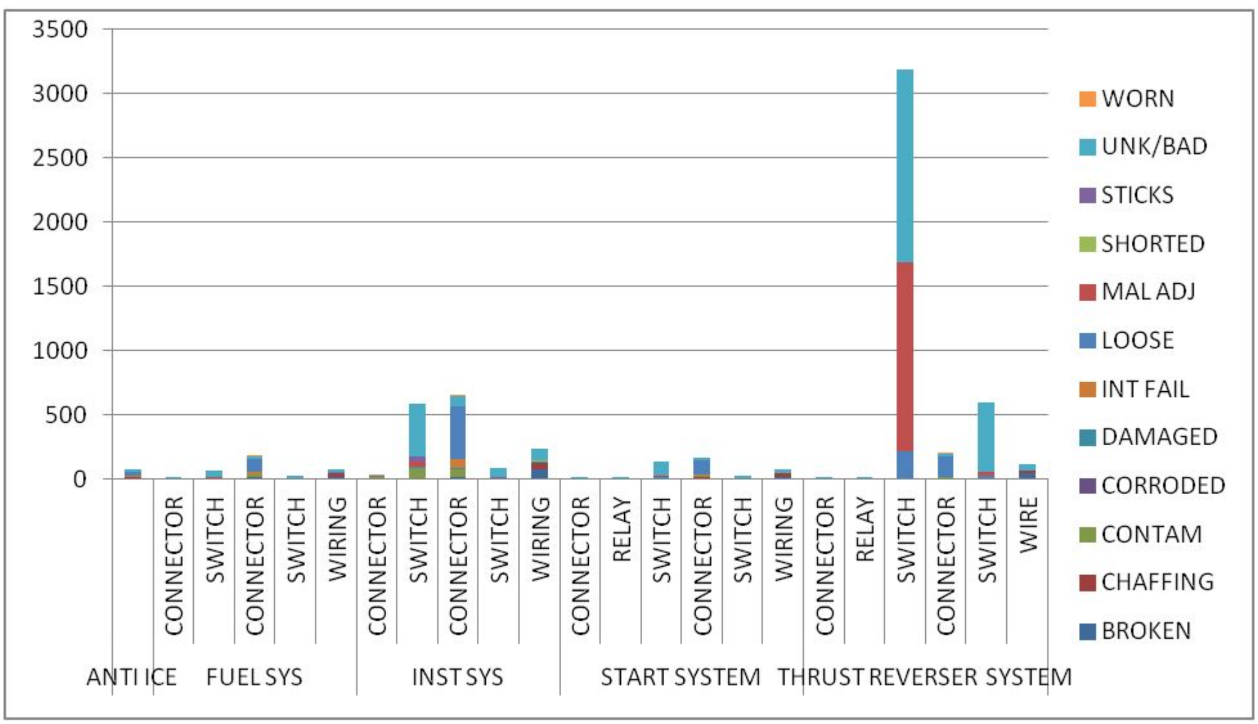


FIGURE C-5. Example of maintenance items categorized by system and device type.

Further research eventually revealed a problem with the latch and extent switches (traced to a single part number) in the TR system that was mitigated by an aircraft modification.

Upon completion of all EWIS and aircraft subsystems data analysis, a report is assembled bringing together a snapshot of all of the systems on the aircraft. This information is used to direct the on aircraft inspections (Task Three); and provide guidance on component removal for degradation analysis (Task Four), reliability data for the risk assessment (Task Five), and data to support an action plan (Task Six).

C.7 Data analysis questionnaire.
Figure C-6 is an example of a questionnaire that will aid in the collection and review of EWIS maintenance data. Ideally the information should be collected by interviewing EWIS maintenance technicians.

Q #	QUESTION	ANSWER
1	Are there any shorthand notations you use (or know others have used) when entering maintenance actions related to electrical wiring system (e.g., “wr” for “wire”, or “btn” for “button”)?	
2	Are there any slang terms that you use (or know others have used) when entering maintenance actions related to electrical wiring system?	
3	Are there any EWIS components that are unique or seem to be specialized for this aircraft?	
4	Is there anything else that might be helpful to someone who would review the maintenance reports for EWIS-related issues?	
5	How many years have you worked on this aircraft fleet?	
6	What is your current position?	

EXAMPLES OF EWIS COMPONENTS		
Wires	Relays	Splices
Fiber Optics	Terminals	Pins
Connectors	Buttons	Circuit Protection
Clamps	Switches	Grounds

FIGURE C-6. Example EWIS maintenance data questionnaire.

APPENDIX D

EWIS TASK THREE – PHYSICAL AIRCRAFT INSPECTION

D.1 SCOPE.

The objective is to provide guidance on the physical inspection programs of all EWIS installed on aircraft and in fulfilling Task Three of this handbook. Application of this information will improve the likelihood that EWIS degradation from many causes—including environmental, maintenance-related, and age-related problems—will be identified and corrected. In addition, this information has been reviewed to ensure maintenance actions such as inspection, repair, overhaul, replacement of parts, and preservation do not: (1) cause a loss of EWIS function, (2) cause an increase in the potential for smoke and fire in the aircraft, and (3) inhibit the safe operation of the aircraft. The guidance provided in this appendix is based on the information provided in MIL-HDBK-522, AC 25-27A, and AC 120-94.

The dependencies of Task Three are shown on figure D-1.

D.2 APPLICABLE DOCUMENTS

D.2.1 General.

The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

D.2.2 Government documents

D.2.2.1 Specifications, standards, and handbooks.

The following specifications, standards, and handbooks form a part of this document to the extent specified herein.

DEPARTMENT OF DEFENSE SPECIFICATION

MIL-W-5088	Wiring, Aerospace Vehicle

DEPARTMENT OF DEFENSE STANDARD

MIL-STD-704	Aircraft Electrical Power Characteristics

(Copies of these documents are available online at https://assist.dla.mil/quicksearch/ or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia PA 19111-5094; [215] 697-2664 USA.)

D.2.2.2 Other Government documents, drawings, and publications.
The following other Government documents, drawings, and publications form a part of this document to the extent specified herein.

DEPARTMENT OF DEFENSE INSTRUCTIONS

NAVAIRINST 13034.1C	Flight Clearance Policy for Air Vehicles and Aircraft Systems

(Copies of this document are available at http://www.navair.navy.mil/nawcwd/vx31/documents/NAVAIRINST13034_1.pdf.)

D.2.3 Non-Government publications.
The following documents form a part of this document to the extent specified herein.

SAE INTERNATIONAL

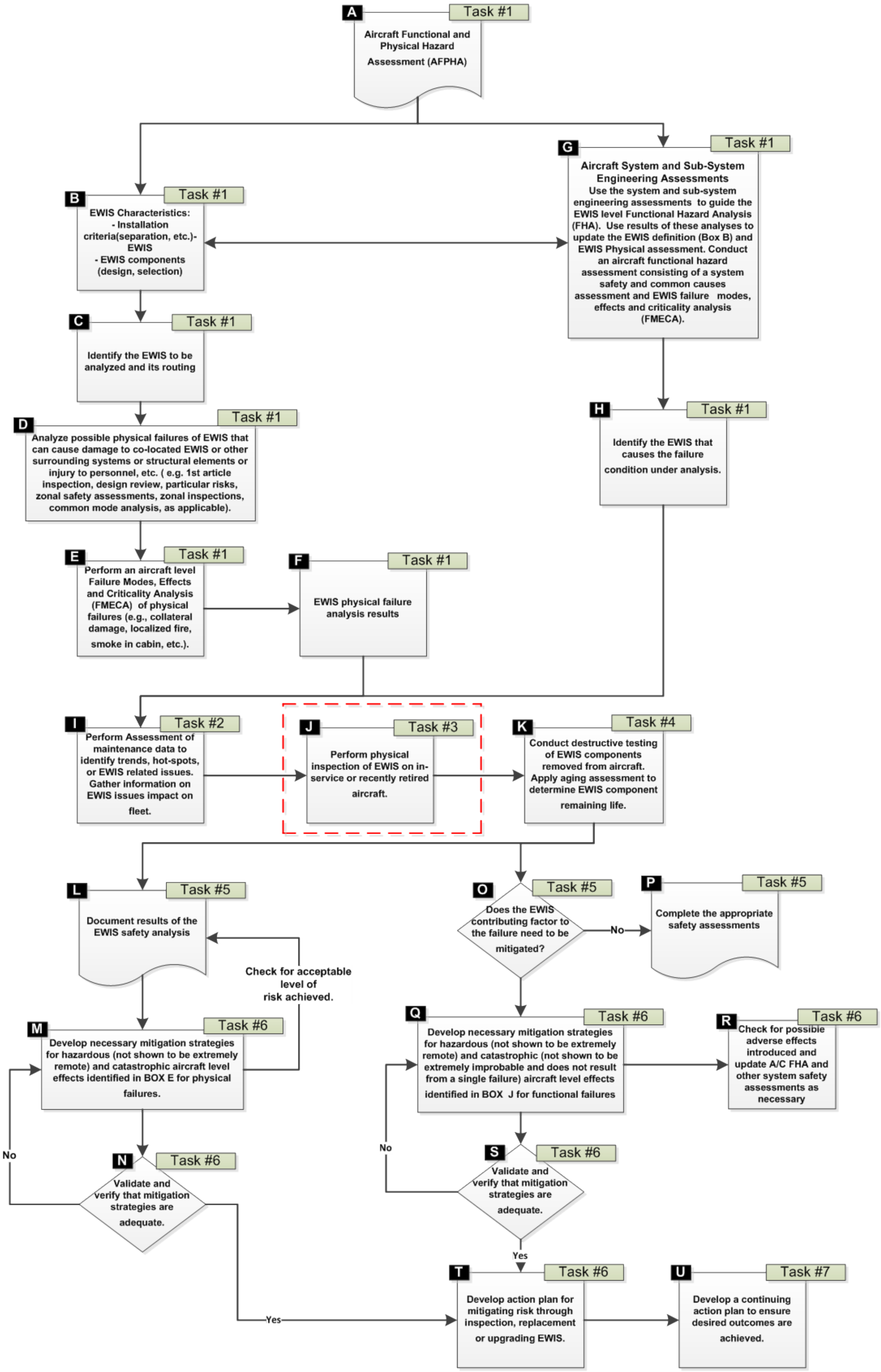
ARP1870	Aerospace Systems Electrical Bonding and Grounding for Electromagnetic Compatibility and Safety
AS22759	Wire, Electrical, Fluoropolymer-Insulated, Copper or Copper Alloy

(Copies of these documents are available from SAE International, 400 Commonwealth Drive, Warrendale PA 15096-0001 USA; www.sae.org.)

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION

ANSI/NEMA WC 27500	Standard for Aerospace and Industrial Electric Cable

(Copies of this document are available from the National Electrical Manufacturers Association, 1300 North 17th Street, Suite 1752, Roslyn VA 22209-3801 USA; www.nema.org.)



NOTE: The red-dashed boxed area includes the Task Three efforts.

FIGURE D-1. Process flow for risk assessment.

D.3 Background.
The guidance in this task is based on recommendations generated by the ATSRAC and experience within Air Force Research Laboratory's (AFRL) Materials Integrity Branch, AFRL/RXSA. It is also drawn from maintenance, inspection, and alteration best practices identified through extensive research by ATSRAC and Federal Government working groups.

It is important to note that performance or physical degradation is not always visible. Micro-cracks in the insulation or heat damage caused by electrical overloads are difficult to see in individual wires, and even more difficult to see in large bundles. The same is true for other EWIS components. Thus, the physical inspection conclusions should not overstate the aircraft condition. This information must be combined with the data analysis, physical degradation, and system failure severity for comprehensive analysis.

D.4 Causes of wire and other EWIS component degradation.
D.4.1 through D.4.10 describe what are considered the principal causes of wiring degradation. Anyone who conducts an inspection program, or develops or performs maintenenace programs should be familiar with these factors and ensure their proper emphasis. EWIS materials degraded due to the mechanisms described here should be considered when a comprehensive materials/aging analysis outlined in Task Four of this handbook is conducted.

D.4.1 Vibration.
High vibration areas tend to accelerate degradation over time, resulting in "chattering" contacts and intermittent symptoms. High vibration of cable ties or string-ties can cause damage to insulation. In addition, high vibration will exacerbate any existing wire insulation cracking.

D.4.2 Moisture.
High moisture areas (above 60 percent Relative Humidity or areas with condensation) generally accelerate corrosion of terminals, pins, sockets, and conductors. Certain insulation types which contain aromatic polyimide material are susceptible to degradation from moisture. High moisture levels can also reduce the insulation resistance of materials and create conductive paths. EWIS component reliability and life is typically extended when installed in clean, dry areas with moderate temperatures.

D.4.3 Maintenance.
Scheduled and unscheduled maintenance activities, if done incorrectly, may contribute to long-term problems and degradation of EWIS. Certain repairs may have limited durability and should be evaluated to ascertain if rework is necessary. Repairs that conform to TO 1-1A-14, the approved aircraft TO on general wire repair practices, or manufacturers' recommended maintenance practices are generally considered permanent and should not require rework.

D.4.4 Metal shavings and debris.
Metal shavings and debris have been discovered on wire bundles after maintenance, repair, or modification has been performed. Work areas should be cleaned while the work is in progress to ensure all shavings and debris are removed. The work area should be thoroughly cleaned after work is complete, and the area should be inspected after the final cleaning.

D.4.5 Repairs.
Repairs should be performed according to the most effective, authorized methods available. Since wire splices are more susceptible to degradation, arcing, and overheating, the recommended method of repairing a wire is with an environmentally-sealed splice. Use guidance from TO 1-1A-14 or the approved aircraft TO on general wire repair practices.

D.4.6 Indirect damage.

Events such as pneumatic duct ruptures or duct clamp leakage can cause damage that, while not initially evident, can later cause wiring problems. When events such as these occur, surrounding EWIS should be carefully inspected to ensure that there is no damage or potential for damage is evident. Indirect damage caused by these types of events could be broken clamps or ties, broken wire insulation, or even broken conductor strands. In some cases, the pressure of the duct rupture could cause wire separation from the connector or terminal strip.

D.4.7 Contamination.

EWIS contamination refers to any of the following situations:

1. a. Presence of a foreign material that is likely to cause degradation of EWIS or

   b. Presence of a foreign material that is combustible or able to sustain a fire after removal of the ignition source. An EWIS contaminant may be in solid or liquid form.
2. Solid contaminants. Solid contaminants, such as the following, can accumulate on wiring and other EWIS components and could degrade or penetrate wiring or other EWIS components:
   a. Metal shavings/swarf,
   b. Debris,
   c. Livestock waste,
   d. Lint,
   e. Dust.
3. Fluid contaminants. Chemicals in fluids, such as the following, can contribute to degradation of wiring and other EWIS components:
   a. Hydraulic fluid,
   b. Battery electrolytes,
   c. Fuel,
   d. Corrosion inhibiting compounds,
   e. Waste system chemicals,
   f. Cleaning agents,
   g. De-icing fluids,
   h. Paint,
   i. Soft drinks,
   j. Coffee/tea.
4. Contaminants requiring special consideration
   a. Special consideration is required for the following:
      1) Hydraulic fluids,
      2) De-icing and lavatory fluids,
      3) Battery electrolyte.
   b. These fluids, although essential for aircraft operation, can damage EWIS components, such as connector grommets, wire bundle clamps, cable ties, and wire lacing, and cause chafing and arcing. EWIS components exposed to these fluids should be given special attention during inspection. Contaminated wire insulation that has visible cracking or breaches to the core conductor can eventually arc and cause a fire. Wire and other EWIS components exposed to, or in close proximity to,

any of the chemicals listed above may need to be inspected more frequently for damage or degradation.

c. When areas or zones of the aircraft which contain both wiring and chemical contaminants are cleaned, special cleaning procedures and precautions may be needed. Such procedures may include wrapping wire connectors and other EWIS components with a protective covering prior to cleaning. This would be especially true if pressure washing equipment is used. In all cases, the aircraft manufacturer's recommended procedures should be followed.

d. Lavatory (waste) system contamination. Lavatory system spills also require special attention. Service history has shown that these spills can have detrimental effects on aircraft EWIS and have resulted in smoke and fire events. When this type of contamination is found, all affected components in the EWIS should be thoroughly cleaned, inspected, and repaired, or replaced as necessary. The source of the spill or leakage should be located and corrected. These fluids are typically highly conductive and alkaline (pH values above 10) and damaging to EWIS components such as relays, switches, connectors, and wire insulation containing aromatic polyimide (Kapton®).

5. Areas of the aircraft subjected to cleaning or exposed to pressure washing should be inspected for physical damage and chemical contamination.

D.4.8 Heat.

Exposure to high heat can accelerate degradation of EWIS by causing wire insulation oxidation, thermal damage, and loss of solvents which leads to loss of mechanical properties and/or cracking. Direct contact with a high heat source can quickly damage insulation. Burned, charred, or even melted insulation is the most likely indicator of this type of damage. Low levels of heat can also degrade wiring over a longer period of time. This type of degradation is sometimes seen on engines, generators, in galley wiring such as in coffee makers and ovens, and behind fluorescent lights, especially ballasts. Sealed cockpits with a glass canopy in direct sunlight can reach elevated temperatures sufficient to damage EWIS components.

D.4.9 Cold.

Exposure to extremely cold temperatures, such as those found at typical cruising altitudes, or wires exposed to cold temperatures while the aircraft is parked in a cold environment, increases the rigidity of wire insulation in those wires that have little or no current flow. Vibration or other types of movement of the EWIS during this time could lead to wire faults. This is important to remember when maintenance to, or around, these wires is performed in a cold environment. EWIS located outside the pressurized fuselage—such as those located in landing gear wheel wells, wing leading and trailing edges, and in the horizontal and vertical stabilizers—are routinely subjected to these extreme cold temperatures.

D.4.10 Severe Wind And Moisture Prone (SWAMP) areas.

Wheel wells, wing folds and areas near wing flaps, and areas directly and extensively exposed to weather conditions are considered SWAMP areas on aerospace vehicles. The EWIS components in these areas require special attention.

D.5 General EWIS maintenance guidance.

Areas to be inspected should be cleaned to minimize the possibility that collected dirt, grease, or other contaminants might hide unsatisfactory conditions which would otherwise be undetected during inspection. Such contamination could cause EWIS component degradation and also prevent an effective General Visual Inspection (GVI) or Detailed Inspection (DET) if it were not cleaned. Additionally, depending on the type and amount present, contaminants may also be combustible and sustain a fire should electrical arcing occur. Follow the aircraft manufacturer's procedures or other methods, techniques, and practices acceptable to the maintainer to perform cleaning considered necessary. The cleaning process itself should not compromise the integrity of the EWIS.

D.5.1 Levels of inspection applicable to EWIS.

Though the term, "detailed visual inspection (DVI)" remains valid for a detailed inspection using only eyesight, this may represent only part of the inspection required in the EWIS Instruction for Continued Airworthiness (ICA) used to establish an operator's maintenance program. The acronym "DVI" should not be used because that term may exclude tactile examination, which is sometimes needed. The following definitions are provided, instead.

D.5.2 General Visual Inspection.

A general visual examination of an interior or exterior area, installation, or assembly will detect only obvious damage, failure, or irregularity. This level of inspection is made from within touching distance unless otherwise specified. A mirror may be necessary to enhance visual access to all exposed surfaces in the inspection area. This level of inspection is made under normal lighting conditions such as daylight, hangar lighting, flashlight, or droplight and may require removal or opening of access panels or doors. Stands, ladders, or platforms may be required to gain proximity to the area being checked. Use Guideline 1 of MIL-HDBK-522 for EWIS inspection procedures.

There is usually no need to remove equipment or displace EWIS when a GVI is performed, unless the access instructions specifically call for it.

The area to be inspected should be clean enough to minimize the possibility that collected dirt, grease, or other contaminants might hide unsatisfactory conditions which would otherwise be obvious. Use the aircraft manufacturer's procedures or other methods, techniques, and practices acceptable to the FAA for any cleaning considered necessary. The cleaning process itself should not compromise the integrity of EWIS. Avoid using high-pressure cleaning and abrasive materials which could damage wire insulation and other EWIS components.

In general, the person who performs a GVI is expected to identify degradation from wear, vibration, moisture, contamination, excessive heat, aging, and so forth, and assess what actions are appropriate to address the discrepancy. This assessment should consider potential effects on adjacent system installations, particularly if those systems include wiring. Any observed discrepancies, such as chafing, broken clamps, sagging, interference, contamination, etc. should be addressed.

An EWIS stand-alone GVI applies the above inspection techniques to wires, cables, and other EWIS components identified in the inspection procedure.

D.5.3 Detailed inspection (DET).

A DET is an intensive examination of a specific item, installation, or assembly to detect damage, failure, or irregularity. Available lighting is normally supplemented with a direct source of good lighting at an intensity deemed appropriate. Inspection aids such as mirrors, magnifying lenses, or other means may be necessary. Surface cleaning and elaborate access procedures may be required. A DET can be more than just a visual inspection, since it may include tactile assessment in which a component or assembly is checked for tightness/security. It may require the removal of items such as access panels and drip shields, or the moving of components.

Detailed inspection procedures for various EWIS components and examples of preferred and unacceptable conditions with respect to SAE AS50881 are given in MIL-HDBK-522. MIL-HDBK-522 should be used to inspect aircraft EWIS and maintain it in an airworthiness condition.

Tactile assessment as used in the context of an EWIS DET does not require the disassembly of wire bundles to inspect individual wires within the bundle.

D.5.4 Zonal inspection.
This is a collective term which describes selected GVIs and DETs applied to each aircraft zone, defined by access and area, to check the component integrity within the zone. A zonal inspection is an inspection of an area or zone to detect unsatisfactory conditions and discrepancies.

D.5.5 EWIS-related guidance for zonal inspections.
The following EWIS degradation conditions are typical of what should be detectable and addressed as a result of a zonal inspection (as well as a stand-alone GVI). Maintenance and training documentation should include these items. This list is not intended to be all-inclusive and may be expanded as appropriate. Existing inspection handbooks (such as MIL-HDBK-522) should be used to supplement the inspection information provided here.

1. Wire/wire harnesses.
    a. See MIL-HDBK-522 Guidelines 2, 3, 5, 6, 7, 11, 12, 14, 15 16, 17, and 18;
    b. Wire bundle/wire bundle or wire bundle/structure contact/chafing,
    c. Wire bundles sagging or improperly secured;
    d. Wires damaged (obvious damage because of mechanical impact, overheat, localized chafing);
    e. Lacing tape and/or ties missing/incorrectly installed;
    f. Wiring protection sheath/conduit deformed or incorrectly installed;
    g. End of sheath rubbing on end attachment device;
    h. Grommet missing or damaged;
    i. Dust and lint accumulation;
    j. Surface contamination by metal shavings/swarf;
    k. Contamination by liquids;
    l. Deterioration of previous repairs (e.g., splices);
    m. Deterioration of production splices;
    n. Inappropriate repairs (e.g., an incorrect splice); and
    o. Inappropriate attachments to or separation from fluid lines.
2. Connectors.
    a. See MIL-HDBK-522 Guidelines 4, 6, 28, 29, 30, 31, and 32;
    b. External corrosion on receptacles;
    c. Backshell tail broken;
    d. Rubber pad or packing on backshell missing;
    e. No backshell wire securing device;
    f. Fool-proofing chain broken;
    g. Safety wire missing or broken;
    h. Discoloration/evidence of overheat on terminal lugs/blocks;

i. Torque stripe misaligned;
j. Broken, bent, or missing pins;
k. Pin or socket corrosion; and
l. Contamination inside connector or on mating surfaces.

3. Switches.
   a. Rear protection cap damaged;
   b. Missing hardware (e.g., screws, washers);
   c. Loose hardware; and
   d. Improper hardware.
4. Ground points.
   a. See MIL-HDBK-522 Guideline 26;
   b. Corrosion; and
   c. Loose hardware.
5. Bonding braid/bonding jumper.
   a. See MIL-HDBK-522 Guideline 26;
   b. Braid broken or disconnected;
   c. Multiple strands corroded; and
   d. Multiple strands broken.
6. Wiring clamps or brackets.
   a. See MIL-HDBK-522 Guidelines 14 and 16;
   b. Corroded;
   c. Broken/missing;
   d. Bent or twisted;
   e. Unstuck/detached;
   f. attachment faulty (bad attachment or fastener missing); and
   g. Protection/cushion damaged.
7. Supports (rails or tubes/conduit).
   a. Broken;
   b. Deformed;
   c. Fastener missing;
   d. Edge protection on rims of feed-through holes missing;
   e. Racetrack cushion damaged; and
   f. Drainage holes (in conduits) obstructed.
8. Circuit breakers, contactors, or relays.
   a. See MIL-HDBK-522 Guideline 33;
   b. Signs of overheating;
   c. Signs of arcing;
   d. Missing hardware (e.g., screws, washers);
   e. Loose hardware; and
   f. Improper hardware.

9. Pressure Seals.
   a. Evidence of seal loss around the bulkhead seal or internally to the connector;
   b. Debris build-up or fuel residue in the connector; and
   c. Cracks or corrosion in the glass-to-metal seals around feed-through pins.

D.6 Wiring installations and areas of concern.
Maintenance material should address the following installations and areas.

D.6.1 Wiring installations.

D.6.2 Clamping points.
Damaged clamps, migration of clamp cushions, or improper clamp installations contribute to wire chafing. Aircraft manufacturers specify clamp type and part number for EWIS throughout the aircraft. Use those specified by the aircraft manufacturer when clamps are replaced. Cable ties provide a rapid method of clamping, especially during line maintenance operations, but improperly installed tie wraps can have a detrimental effect on wire insulation. When new wiring is installed as part of a TCTO, AFB, or other modification, the drawings will provide wire routing, clamp type and size, and proper location. Examples of significant wiring alterations are the installation of new avionics systems, new galley equipment, and new instrumentation. Wire routing, type of clamp, and clamping location should conform to the approved drawings. Adding new wire to existing wire bundles may overload clamps, and cause wire bundles to sag and wires to chafe. Raceway clamp foam cushions may deteriorate with age, disintegrate, and thus fail to provide proper clamping.

Particular attention is required where wire bundles normally flex or move when doors and panels are opened and closed. Inspect for improper usage of clamps and clamp cushions with types not compatible for the installation environment. Any evidence of loose clamps, lacing tape ties, cable ties, loose or damaged bundle clamp standoffs, distorted bundle clamp support brackets, or improper usage of clamps or clamp cushions is considered a discrepancy.

D.6.3 Connectors.
Worn environmental seals, loose connectors, missing seal plugs, missing dummy contacts, or lack of strain relief on connector grommets can compromise connector integrity and allow contamination to enter the connector and lead to corrosion or grommet degradation. Connector pin corrosion can cause overheating, arcing, and pin-to-pin shorting. Drip loops should be maintained when connectors are below the level of the harness, and tight bends at connectors should be avoided or corrected.

Inspect potting of connectors or feed-through bushings for proper sealing, cracking, or deterioration. Look for contamination tracks, and burn marks across potting material to metals. Pay close attention to vertically-oriented connector parts for evidence of moisture. Evidence of improper sealing, cracking, deterioration, moisture, or burn marks of potting is a discrepancy.

Inspection of connector internals (pins, internal contamination, etc.) is dependent upon where the physical inspection is performed and may not be possible in all conditions. The connector assessment level should be coordinated with the aircraft maintainer.

D.6.4 Terminations.
Terminations, such as terminal lugs and terminal blocks, are susceptible to mechanical damage, corrosion, heat damage, chemical contamination, dust, and dirt. Over time, vibration can cause high-current-carrying feeder cable terminal lugs to lose their original torque value and result in

arcing. One sign of this is heat discoloration at the terminal end. Proper build-up and nut torque is especially critical on high-current-carrying feeder cable lugs. Corrosion on terminal lugs and blocks can cause high resistance and overheating. Dust, dirt, and other debris are combustible and could sustain a fire if ignited from an overheated or arcing terminal lug. Terminal blocks and terminal strips located in equipment power centers (EPC), avionics compartments, and throughout the aircraft need to be kept clean and free of combustibles.

D.6.5 Backshells.

Wires may break at backshells from excessive flexing, lack of strain relief, or improper build-up. Loss of backshell bonding may also occur because of these and other factors.

D.6.6 Sleeving and conduits.

Damage to sleeving and conduits, if not corrected, may lead to wire damage. Damage such as cuts, dents, and creases on conduits may require further investigation for condition of wiring within.

D.6.7 Grounding points.

Grounding points should be checked for security (i.e., finger tightness), condition of the termination, presence of corrosion, compliance with platform maximum fill requirements, and cleanliness. Grounding points which are corroded, loosened, or lost their protective coating should be repaired.

D.6.8 Harness protection.

Harness protective systems (used to protect wiring from chafing, heat, or electromagnetic interference) may become brittle or chaffed. The harness protection should be examined for wear, heat damage, or increased stiffness.

D.6.9 Pressure seals.

A pressure seal is an area where a wire bundle passes through a pressure bulkhead via a bulkhead connector. Examples would be between a pressurized and unpressurized bay or where one side of a connector is in a fuel compartment and the other side is in a dry bay area. Pressure seals may also be used when a wire bundle passes through a firewall and other openings in the structure. This is typically a hermetic connector with glass-to-metal seal in the connector pin feed-through; the feed-through may also use an elastomeric grommet cork-and-bottle type seal.

Inspection should concentrate on evidence of seal loss around the bulkhead seal and internally to the connector. There may be evidence of debris build-up or fuel residue in the connector. These connectors typically contain feed-through pins in a glass-to-metal seal which can crack or exhibit corrosion. A grommet based feed-through seal is less robust than a glass-to-metal seal and must be inspected periodically for evidence of seal failure.

D.6.10 Splices.

Both sealed and non-sealed splices are susceptible to vibration, mechanical damage, corrosion, heat damage, chemical contamination, and environmental deterioration. Power feeder cables normally carry high current levels and are very susceptible to installation error and splice degradation. All splices should conform to the TAA published recommendations. All splices should conform to the authorized Technical Manual.

D.6.11 Areas of concern

D.6.11.1 Wire raceways and bundles.

Addition of wires to existing wire raceways may cause undue wear and chafing of the wire installation and inability to maintain the wire in the raceway. Addition of wires to existing bundles may cause wire to sag against the structure, which can cause chafing.

D.6.11.2 Wings.

Wing leading and trailing edges are difficult environments for wiring installations. On some aircraft models, wing leading and trailing edge wiring is exposed whenever the flaps or slats are extended. Slat torque shafts and bleed air ducts in these areas are other potential damage sources.

D.6.11.3 Engine, pylon, and nacelle area.

These areas experience high vibration, heat, and frequent maintenance, and are susceptible to chemical contamination.

D.6.11.4 Accessory compartment and equipment bays.

These areas typically contain items such as electrical components, pneumatic components and ducting, and hydraulic components and plumbing. They may be susceptible to vibration, heat, and liquid contamination.

D.6.11.5 Auxiliary power unit (APU).

Like the engine/nacelle area, the APU is susceptible to high vibration, heat, frequent maintenance, and chemical contamination.

D.6.11.6 Landing gear and wheel wells.

This area is exposed to SWAMP in addition to vibration and chemical contamination.

D.6.11.7 Electrical panels and LRUs/WRAs.

Electrical panel wiring is particularly prone to broken wires and damaged insulation when these high-density areas are disturbed during troubleshooting activities, modifications, and refurbishments. Tying wiring to wooden dowels to reduce its disturbance during modification can minimize wire damage. For some configurations, use of connector support brackets would be more desirable and cause less wire disturbance than removal of individual connectors from the supports.

D.6.11.8 Batteries.

Wires and other EWIS components in the vicinity of all aircraft batteries are susceptible to corrosion and discoloration and should be inspected for those problems. Inspect discolored wires and other EWIS components for serviceability.

D.6.11.9 Power feeders.

High-current wire and associated connections have the potential to generate intense heat. Vibration may cause degradation or loosening of power feeder cables, terminals, and splices. If signs of overheating are seen, splices or termination should be replaced. For both galley and engine/APU generator power feeders, depending on the design, service experience may indicate a need for periodic checks of proper torque on power feeder cable terminal ends, especially in high vibration areas.

D.6.11.10 Under galleys, lavatories, and cockpit.
Areas under the galleys, lavatories, and cockpit are particularly susceptible to contamination from such things as coffee, food, water, soft drinks, lavatory fluids, dust, and lint. Correct floor panel sealing procedures can minimize such contamination in these areas.

D.6.11.11 Fluid drain plumbing.
Leaks from fluid drain plumbing could lead to contamination of EWIS. Service experience may show a need for periodic leak checks or cleaning, in addition to routine visual inspections.

D.6.11.12 Fuselage drain provisions.
Some installations include plumbing features designed to catch leakage and drain it to an appropriate exit. Blockage of the drain path can result in contamination of the EWIS. In addition to routine visual inspections, service experience may signal a need to check these installations and associated plumbing periodically to ensure the drain path is free of obstructions.

D.6.11.13 Cargo bay underfloor.
Damage to EWIS in the cargo bay underfloor can occur from maintenance activities in the area.

D.6.11.14 EWIS subject to movement.
Wiring and other EWIS components which are subject to movement or bending during normal operation or maintenance access, at locations such as doors, actuators, landing gear mechanisms, and electrical access panels, should be inspected at those areas where movement occurs.

D.6.11.15 Access panels.
EWIS near access panels could be accidentally damaged from repetitive maintenance access and may warrant special attention.

D.6.11.16 Under doors.
Areas under cargo, passenger, and service entry doors are susceptible to fluid entering from rain, snow, and liquid spills. Fluid drain provisions and floor panel sealing in these areas should be periodically inspected and repaired as necessary.

D.6.11.17 Under cockpit sliding windows.
Areas under cockpit sliding windows are susceptible to water entering from rain and snow. Fluid drain provisions in these areas should be periodically inspected and repaired as necessary.

D.6.11.18 Areas where EWIS is difficult to access.
Areas difficult to access, such as flight deck instrument panels and the cockpit pedestal, could accumulate excessive dust and other contaminants because of infrequent cleaning. In these areas, it may be necessary to remove components and disassemble other systems to facilitate access to the area.

D.6.11.19 Severe Wind And Moisture Prone areas.
Areas such as wheel wells, wing folds and areas near wing flaps, and areas directly exposed to extended weather conditions are considered SWAMP areas on aerospace vehicles.

D.6.11.20 Separation distance from structure and hydraulic/fuel lines.
Inspect wiring for the minimum clearance (½ inch) from structure, surfaces, and equipment. Where a minimum clearance (½ inch) cannot be maintained, a tighter minimum clearance ($^3/_8$ inch) is acceptable where anti-chafing material is used. Ensure a minimum clearance (2 inches) between wiring and fluid-carrying lines, tubes, and equipment is maintained. When

there is less than acceptable clearance between wiring and fluid-carrying lines, there must be a positive means (clamp) to maintain a minimum (½ inch) clearance. Improper clearance between wiring, fluid-carrying lines, tubes, and equipment, or lack of or improperly-installed anti-chafing material is a discrepancy.

D.6.11.21 Separation from other components.
Inspect for proper wiring clearance from linkages, throttle controls, boxes, covers, structures, control cables, and component mounting hardware. Improper wiring clearance from linkages, throttle controls, boxes, covers, structures, control cables, and component mounting hardware is a discrepancy.

D.6.11.22 EWIS component identification.
Inspect all wiring for secure and legible connector identifications in accordance with MIL-W-5088 or SAE AS50881. Illegible or missing identification is a discrepancy.

D.7 Selection of aircraft.
The representative aircraft is the configuration of each series aircraft model that incorporates all variations of EWIS used in production on that series aircraft, and all designed modifications mandated. For example, a particular aircraft model may be offered in various configurations depending on mission requirements. For a given aircraft model, the resultant EWIS examination must account for any differences between configurations. The placement of galleys, lavatories, equipment, and other interior furnishings might impact the type inspections identified. The resultant EWIS inspection plan must reflect such differences.

Ideally, the physical EWIS inspection should be performed when a representative aircraft is at the heavy maintenance level, when many of the aircraft panels have been opened or removed. Inspections performed on in-service aircraft are likely to be more access- and time-limited, which limits the inspection detail possible.

D.8 Selection of EWIS components for inspection.
All EWIS components should be physically examined to the best of the inspection team's ability. A plan should be developed prior to the aircraft inspection to identify which equipment, floor boards, and/or panels will need to be removed to provide inspection access. High-failure EWIS components identified in Task Two should be specifically included in the inspection plan. A checklist should be developed for each area to ensure all identified components are properly inspected.

D.9 Electrical characterization.
The use of electrical characterization tools can supplement the physical assessment. Some of these tools provide the capability to assess circuit breaker boxes and relay panels, identify hard shorts and high resistance in wiring or connections, and measure impedance. It can be advantageous to coordinate the physical inspection with a scheduled automatic test system characterization of the electrical system.

D.10 Inspection report.
After completion of the physical examination, a report should be prepared which details the findings from the inspection. The report should include photographs of discrepancies found during the inspection. Any items identified during the inspection process which may impact aircraft airworthiness should be addressed immediately with corrective actions.

D.11 Skills of personnel performing inspection.
The following skills and knowledge of specifications which govern them are necessary to conduct an aircraft wiring assessment:

a. Wiring, Aerospace Vehicle: SAE AS50881 (version applicable to aircraft),
b. Wiring, Aerospace Vehicle: MIL-W-5088 (version applicable to aircraft),
c. NAVAIR 01-1A-505 Wiring Maintenance Manual (Volumes -1, -2, -3 and -4),
d. Aircraft Electric Power Characteristics, MIL-STD-704 (version applicable to aircraft),
e. Fiber Optic Cabling Systems Requirements and Measurements, MIL-STD-1678,
f. Selection and Installation of Aircraft Electric Equipment, MIL-STD-7080,
g. Aerospace Systems Electrical Bonding and Grounding for Electromagnetic Compatibility and Safety, SAE ARP1870,
h. FAA Airworthiness Certification; FAR Part 21, Part 23, Part 26, Part 121, Part 123,
i. Acceptable Methods, Techniques, and Practices - Aircraft Inspection and Repair; FAA AC-43.13-1B, Ch.11,
j. Flight Clearance Policy for Air Vehicles and Aircraft Systems, NAVAIRINST 13034.1C,
k. Airworthiness Certification Criteria, MIL-HDBK-516, and
l. Governing Wiring Specifications, SAE AS22759 and WC27500; Platform Detailed Specification (SD), etc.

Knowledge and demonstrated experience with the following:

a. Aircraft Ground Operations/Safety,
b. Systems/Structures Terminology,
c. Electrical Drawing Interpretation,
d. Installation Drawing Interpretation,
e. Airworthiness Training, and
f. FAA Functions and requirements Leading to Airworthiness Approval (applicable for commercial derivative aircraft).

Enhanced Zonal Analysis - Details of Zone

Zone Number [ ] **Zone Description** [ ]

- [ ] Hydraulic Plumbing
- [ ] Hydraulic Components (Valves, Actuators, Pumps)
- [ ] Pneumatic Plumbing
- [ ] Pneumatic Components (Valves, Actuators)
- [ ] EWIS - Power Feeder (High Voltage, High Amperage)
- [ ] EWIS - Motor-Driven Devices
- [ ] EWIS - Instrumentation and Monitoring
- [ ] EWIS - Data bus
- [ ] Electrical Components
- [ ] Primary Flight Control Mechanisms
- [ ] Secondary Flight Control Mechanisms
- [ ] Engine Control Mechanisms
- [ ] Fuel System Components
- [ ] Insulation
- [ ] Oxygen System Components
- [ ] Potable Water System Components
- [ ] Waste Water System Components

COMMENTS

FIGURE D-2. Inspection worksheets.

Enhanced Zonal Analysis - Hostility of Environment and Likelihood of Accidental Damage

Zone Number | | **Zone Description** | |

Hostility of Environment	
1 - Passive / 2 - Moderate / 3 - Severe	
Temperature	
Vibration	
Chemicals (toilet fluids, de-icing fluid, etc.)	
Humidity	
Contamination	
Shock	
Other	
Enter the Highest Number.	

Likelihood of Accidental Damage	
1 - Passive / 2 - Moderate / 3 - Severe	
Ground Handling Equipment	
Foreign Object Debris (FOD)	
Weather Effects (hail, rain, etc.)	
Frequency of Maintenance Activities	
Fluid Spillage	
Crew Traffic	
Other	
Enter the Highest Number.	

		Zone Size		
		Small	**Medium**	**Large**
Density	**Low**	1	2	3
	Medium	2	2	3
	High	2	3	3

FIGURE D-2. Inspection worksheets – Continued.

Aircraft Physical Inspection Log

Date	______	**Name(s) of assessor(s)**	______	**Tail Number**	______
Location	______	**Aircraft Model**	______	**Page #**	______

Line #	**Zone**	**Subzone/ Area/ Access Panel**	**Harness ID**	**Wire ID(s)**	**Discrepancy Description**	**Notes**	**Ease of access (1 - Low, 2 - Mid, 3 - High)**	**Photo #'s**
1								
2								
3								
4								
5								
6								
7								
8								
9								

FIGURE D-2. Inspection worksheets – Continued.

APPENDIX E

EWIS TASK FOUR – COMPONENT ASSESSMENT

E.1 SCOPE.

Selective sampling of EWIS devices becomes necessary to determine the current and future health condition of the fleet's EWIS. The health assessment of a component may be limited to pass/fail conditions, or provide information on the future system reliability, depending on the device type and industry research on the particular component. This task focuses on a destructive materials/aging analysis of wiring and electrical components removed from the aircraft based on information gathered in earlier tasks. Guidance is provided on processes and sampling techniques associated with EWIS component assessment and is based on information provided in MIL-R-5757, MIL-STD-202G, MIL-STD-1678, and DOT/FAA/AR-08/2.

E.2 APPLICABLE DOCUMENTS

E.2.1 GENERAL.

The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

E.2.2 Government documents

E.2.2.1 Specifications, standards, and handbooks.

The following specifications, standards, and handbooks form a part of this document to the extent specified herein.

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-DTL-17	Cables, Radio Frequency, Flexible and Semirigid
MIL-DTL-3950	Switches, Toggle, Environmentally Sealed
MIL-R-5757	Relays, Electromagnetic, General Specification

DEPARTMENT OF DEFENSE STANDARD

MIL-STD-202	Electronic and Electrical Component Parts

(Copies of these documents are available online at https://assist.dla.mil/quicksearch/ or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia PA 19111-5094; [215] 697-2664 USA.)

E.2.2.2 Other Government documents, drawings, and publications.

The following other Government documents, drawings, and publications form a part of this document to the extent specified herein.

FEDERAL AVIATION ADMINISTRATION (FAA)

DOT/FAA/AR-08/2	Aircraft Wiring Degradation Study

(Copies of this document are available online at www.faa.gov.)

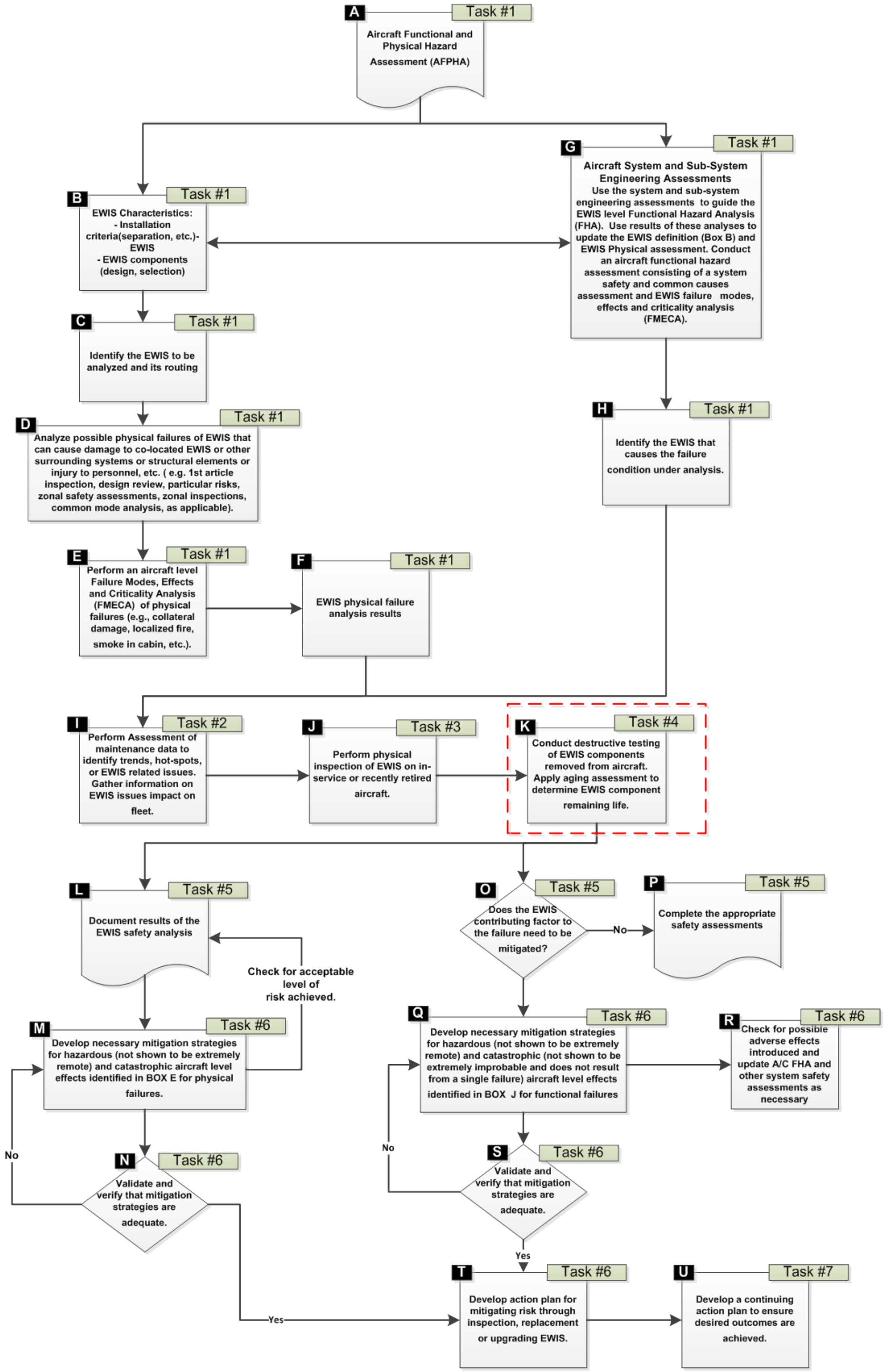
E.3 OVERVIEW.

There are two main goals for the EWIS component assessment:

1. Determine the current condition of the EWIS components; and
2. Determine the remaining component service life.

This process, with regard to the current EWIS component condition, seeks to identify whether the equipment is currently able to meet the performance requirements for the platform (cases in which the component does not meet minimum specifications may require immediate action to assess the susceptibility of the fleet).

The term, “remaining life” used herein refers to how much time remains in the device’s life cycle before age-related failures (wear-out failures) begin to emerge. When EWIS components are tested to failure, the degradation and remaining cycles (or years of service) can be assessed and used in the overall risk assessment outlined in Task Five. Thus, the emphasis on destructive testing in this handbook. The integration of the component assessment performed in Task Four is shown on figure E-1.



NOTE: The red-dashed boxed area includes the Task Four efforts.

FIGURE E-1. Process flow for risk assessment.

E.4 EWIS devices to be considered for assessment.
The following is a list of devices included in the EWIS degradation assessment. Information gathered from either the data analysis (Task Two) or inspection (Task Three) should be used to add or remove devices from this list as applicable to the specific platform. Compare condition of components with new (unused) components. Apply aging assessment techniques and aging/degradation models to determine remaining life of EWIS components.

1. Wire insulation and conductor integrity (E.5.5)
2. Protective harness materials (E.5.6)
3. Shield and ground terminations (E.5.7)
4. Connector contact integrity and shield effectiveness (E.5.8)
5. Circuit breaker contact integrity and the trip curve verification (E.5.9)
6. Relay contact integrity and actuation performance (E.5.10)
7. Switch contact integrity and actuation performance (E.5.11)
8. Electrical distribution panels (E.5.12)
9. Terminal boards, ground studs, and connector back shells (E.5.13)

E.5 Device assessment methods.
The assessment methods described herein for the devices listed are not all inclusive, but are representative of the factors which should be considered through EWIS degradation assessment tests. Additional technologies and assessment methods may be available. These should be evaluated prior to selection of a particular assessment technique.

Further, many of the assessment methods described herein require specialized equipment and should be performed by a laboratory or organization with knowledge and experience of the component degradation.

E.5.1 General assessment techniques.
There is commonality between the devices and the assessments that are recommended through the EWIS component evaluation process. The following are standard evaluations which should be performed on all components selected for testing.

E.5.2 Visual Inspection.
Conduct a laboratory visual and optical inspection to document condition of components and follow with a detailed materials and aging analysis of selected EWIS components. Any anomalies (e.g., discoloration, deformation, wear, etc.) should be noted. This inspection should be performed on all components selected for testing.

E.5.3 Corrosion.
All points on EWIS components that conduct electricity should be examined for corrosion. This includes connection and contact points for devices and the conductors for wiring.

E.5.4 Contact resistance.
The contact points on devices that make and break electrical current—such as switches, relays, and circuit breakers—can create resistance points through use and wear. These resistance points can slow device activation and create a source for heat generation.

A common method to determine contact integrity and measure contact resistance is with a Kelvin Bridge or four-point probe. The method to measure contact resistance is discussed in MIL-STD-202G, Method 307 (Contact Resistance).

E.5.5 Wire insulation and conductor integrity.
The wiring examined during these evaluations is the wire that runs in the chassis of the aircraft, not wiring in LRUs/WRAs. There are several common wire types on aircraft. A brief description of methods for their assessment follows.

E.5.5.1 Aromatic polyimide insulations (common name, Kapton®).
This is a common wire insulation type on many older platforms. This material has been extensively researched and several testing techniques have been developed for its degradation assessment. The following techniques have been found as means to assess the wire condition.

1. Force hydrolysis: This technique has been found to work with periodic dielectric testing to forecast the remaining life of the polyimide wire.
2. Inherent viscosity: As polyimide ages, the polymer chains break down and make the polymer more susceptible to crack growth from mechanical strain. Inherent viscosity testing identifies polymer chain reduction and has been used to forecast remaining life.
3. Tensile elongation and elongation to break: Research has shown these tests track with the polymer degradation and reduction of physical properties.

E.5.5.2 XL-ETFE (common name, Tefzel®).
Current research suggests the primary cause for wire degradation is exposure to heat. Failure models have been developed for XL-ETFE and are based on examination of the insulation tensile and elongation mechanical properties, discovered primarily through tensile elongation test.

E.5.5.3 Composite insulations (common name, Teflon-KAPTON-Teflon® (TKT).
The particular degradation mechanisms for this wire construction are still not well understood despite this insulation's use on aircraft for more than 20 years. The insulation consists of an extruded Teflon® (which is chemically inert) layer on top of polyimide tape. The Teflon® layer provides the moisture barrier and the polyimide tape provides the abrasion strength.

Degradation of the insulation has been identified through inherent viscosity and tensile elongation tests.

E.5.5.4 Fiber optic cable.
Methods to assess the condition of fiber optic cabling may include specification tests and/or measurement of signal attenuation.

E.5.5.5 Coax cables.
There is not yet a well-established degradation model for coaxial cables. Test performed may include specification tests and/or measurement of impedance or signal attenuation. (See MIL-DTL-17H.)

E.5.6 Protective harness materials.
There are a variety of protective sleeving materials with different chemical compositions. There may be degradation models developed for these materials, but examination of these materials should focus on physical inspection for wear and stiffening.

E.5.7 Shield and ground terminations.
The shielding for cables and ground terminations should be visually examined for physical damage and corrosion. Where applicable, the contact resistance should also be measured.

E.5.8 Connector contact integrity and shield effectiveness.
The contact resistance should be measured as discussed in the general test section.

E.5.9 Circuit breaker contact integrity and the trip curve verification.
There are five areas that should be considered for evaluation of circuit breakers. These include:

1. Pull force,
2. Thermal Degradation,
3. Corrosion,
4. Contact resistance, and
5. Trip curve and response time conformance.

E.5.9.1 Pull force.
Pull force evaluation will determine if the circuit breaker is operating within specification and will also provide information as to whether the circuit breaker contacts were welding or corroded together. For example, the circuit breaker pull test results in figure E-2 indicate both were operating within the operation specifications.

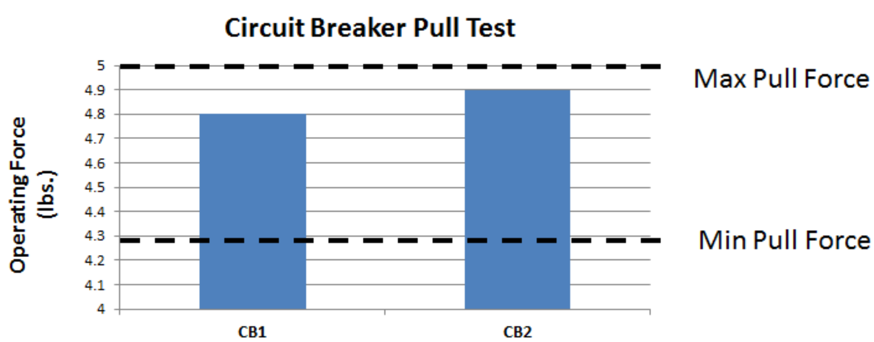


FIGURE E-2. Circuit breaker pull tests.

E.5.9.2 Thermal degradation.
Examine circuit body and terminals for discoloration.

E.5.9.3 Corrosion.
The terminals should be examined for any visible signs of corrosion.

E.5.9.4 Contact resistance.
The contact resistance should be measured as discussed in the general test section.

E.5.9.5 Trip curve and response time.
The response time testing for the circuit breakers evaluates the reaction time to overload conditions. An example of two circuit breaker response times for four over-current conditions is depicted on figure E-3. The figure shows the typical thermal circuit breaker trip curve with the response times of two circuit breakers overlaid. Circuit breaker #1 (blue) was found to operate within the specified limits for all tests, whereas circuit breaker #2 (orange) response time is outside the specified operating limits for this circuit breaker. A quick method to evaluate the functional performance of a circuit breaker is through use of a 200-percent overload test.

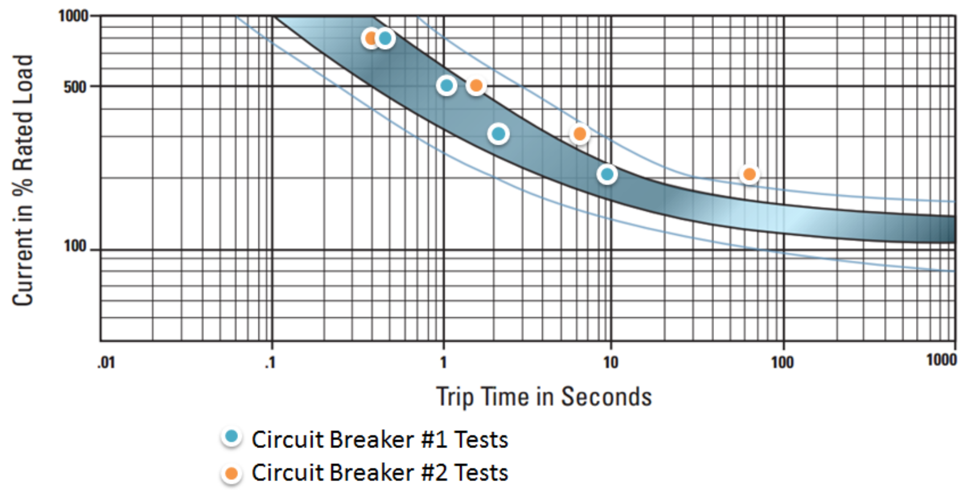


FIGURE E-3. Test results of circuit breaker trip tests.

E.5.10 Relay contact integrity and actuation performance.
Relays should be visually examined and contact resistance checked for all positions. Furthermore, the relay activation should be tested to failure via the method similar to one described in MIL-R-5757J, section 4.6.20, "Life test." This test sets an expected life of the relay at 100,000 or 50,000 cycles depending on type of activation device test condition. These can be used as a basis to develop pass-fail criteria.

E.5.11 Switch contact integrity and actuation performance.
Switches should be visually examined and the contact resistance checked for all positions. Furthermore, the actuation performance should be examined in testing similar to MIL-DTL-3950H, method 4.8.6, "Strength of toggle lever, pivot, and lever stop".

E.5.12 Electrical distribution panels.
Junction boxes should be securely mounted to the aircraft structure; examine for broken attachment hardware. Check for chafing of wire harnesses associated with the junction box and ensure connectors are securely tightened. Examine for thermal damage and corrosion or evidence of water or fluid contamination.

E.5.13 Terminal boards, ground studs, and connector back shells.
Check for loose or damaged connections, residues between electrically isolated terminals, and presence of corrosion. Note thermal damage or arcing evidence on terminals or ground studs.

E.6 Compare condition of components with new (unused) components.
The components, where possible, should be tested and compared against test data of new (unused) components. This validation provides additional check on the results of the degradation analysis and expected limits on the device performance.

E.7 Component selection.
The selection of how many components are required for a degradation assessment and the environment the component is removed from are important considerations. Because there can be variability between aircraft models and devices, care should be taken to gather information on the variability of the component (make, model, manufacturer, etc.). Where practical, logical groupings of aircraft and components should be made to reduce the necessary test sample size. Selection of components should also consider samples with varying degrees of age, exposure to environment, and maintenance. See section D.5 for additional guidance.

E.8 Aircraft selection.
While it would be ideal to test only one aircraft for representative sampling of a fleet, this is not representative of an entire fleet. The impact of the operational history and service locations can greatly impact the degradation of EWIS components. This requires an understanding of the fleet usage history to allow for logical aircraft grouping. Just as grouping of aircraft zones reduced the number for testing, the logical grouping of fleet aircraft identifies the selective sampling partitions. This process ensures the validity and applicability of risk assessment results.

After the groups have been created, the next step is to determine which aircraft within these groups should be selected for testing. The aircraft within these groups are typically those that are most available for wire removal (e.g., depot-level maintenance or recently retired).

E.8.1 Selection factors.
The selection of aircraft for sample selection should be based on the critera described in E.8.1.1 through E.8.1.4.

E.8.1.1 Availability.
A requirement to remove samples from in-service aircraft should coincide with depot-level maintenance actions. Sufficient time should be allotted for removal and replacement of any components. Care should be taken to limit testing of obsolete or long lead-time components.

E.8.1.2 Accessibility.
Some EWIS components can be located or routed in areas not often accessed during the aircraft's life; the removal of components or structure to access the areas may be high-cost actions. The location of the equipment should be considered prior to removal and can drive the selection of components for removal.

E.8.1.3 Age.
As this effort is part of a service life extension program, the aircraft selected should be those that are among the oldest in the fleet with consideration of flight and calendar time.

E.8.1.4 Service locations.
The EWIS components can degrade differently based on different service locations. Hot, humid environments will impact the degradation of components more than cool, dry environments. As such, the aircraft service locations should also be a contributing factor about which aircraft are selected.

E.8.2 Sample size.
Sample size is important when degradation analysis and destructive testing of system components is performed. A proper sample size is selected to reflect the variability of conditions on the aircraft accurately.

A sound sample size provides sufficient information about the system without the need to test every component. Considerations for determination of the sample size should include:

1. Variability between environments within the aircraft,
2. Component age, and
3. Aircraft age.

Representative sampling assessment should be coordinated with the testing body to ensure a sufficient number of samples are taken. At a minimum, at least 3 components should be tested for each degradation assessment. The degradation assessment for the wiring should acquire at least 12 test samples per environmental zone.

E.9 Test performance.
The particular type of testing is based on the component tested, and a variety of test options may be available within each component class. Different methods to determine the degradation of components were identified in section E.5.

E.10 Test results.
The results will be presented differently dependent on the type of degradation model available for the given component. Pass/fail criteria should be established if no degradation model has been developed. The pass/fail criteria should be set such that, at a minimum, the component will likely continue to function in the worst-case environment until the next depot-level maintenance. A Subject Matter Expert should help define the pass/fail threshold.

If a simplified degradation model has been developed, then this may include multiple levels of life condition. The following is an example of this partitioning:

Like new (greater than 75 percent of life remaining)

Limited wear (between 45 percent – 75 percent)

Near end of life (between 15 percent – 45 percent)

End of life (less than 15 percent of life remaining).

These partitioning should be changed based on the available component degradation data and fleet sustainability needs.

More advanced degradation models can, with the aid of destructive testing data, identify the component degradation and the remaining years of continued service before age-related failures will start to emerge. These models are often specialized to one particular type of component.

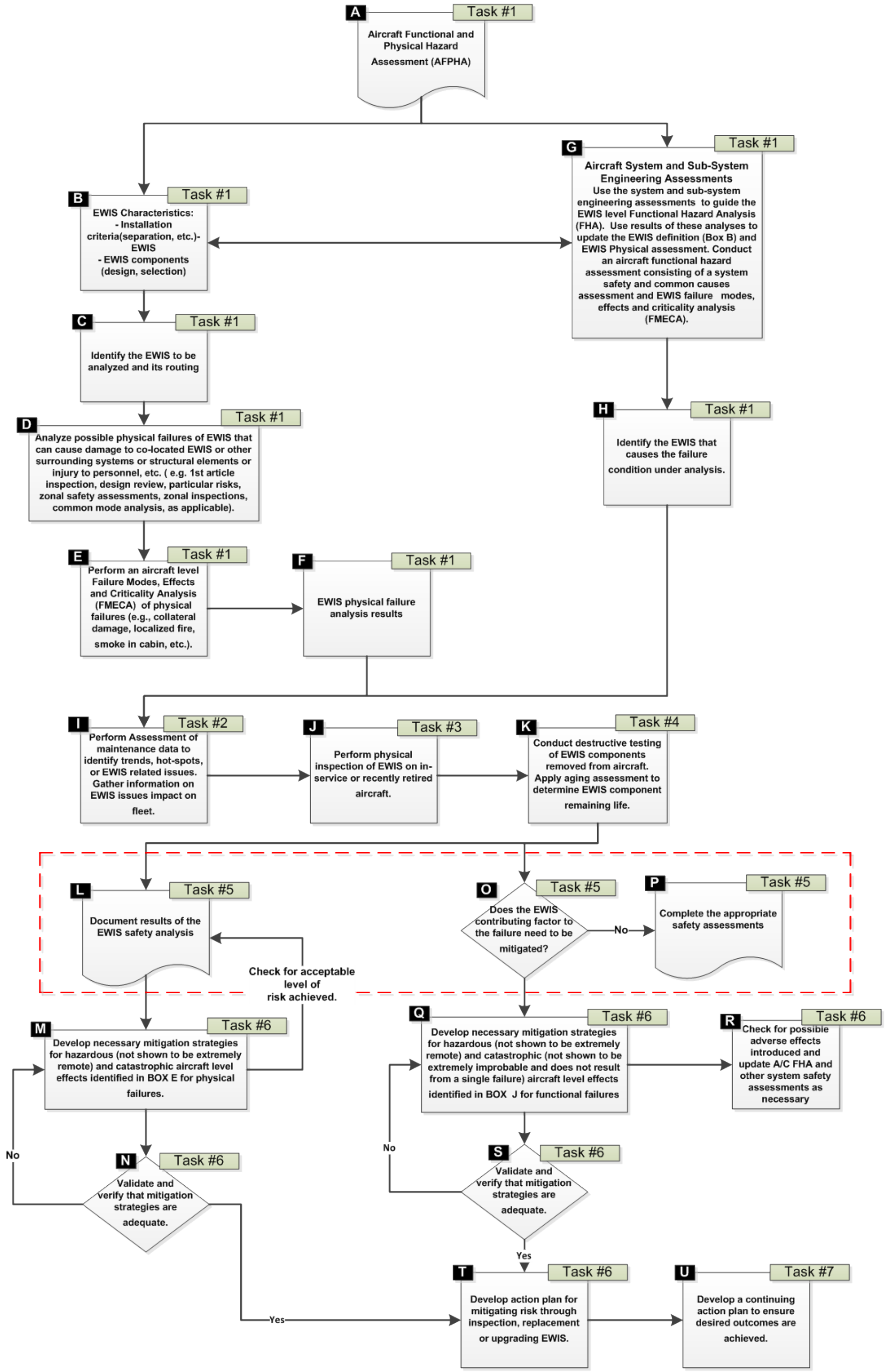
E.11 Task report.
The final task for the component degradation assessment is the delivery of a final report. This report should describe condition of EWIS components and available life forecast data. This data may be reported at the device, system, or zonal level.

APPENDIX F

EWIS TASK FIVE – RISK ASSESSMENT

F.1 SCOPE.

This task combines the results of the previous four tasks for the development of an EWIS risk assessment. If unsafe conditions are identified during this task, this task may be revisited pending the determination of risk tolerance in Task Six. In the subsequent Task Six, mitigation strategies may be developed and require re-evaluation of the aircraft (or system) risk. In such a case, only a subsection of this task may need to be repeated to determine a modification in risk. The integration of the Task Five with the overall EWIS risk assessment effort is shown on figure F-1. The guidance provided in this appendix is based on the information provided in AC 25-27A, AC 25.1701-1, AC 120-97A , and MIL-STD-882.



NOTE: The red-dashed boxed area includes the Task Five efforts.

FIGURE F-1. Risk assessment process flow.

F.2 Documentation of EWIS results.
Box L: Document EWIS assessment (figure F-1): Document the results of the risk assessment after mitigation strategies have been validated and verified. Update, as necessary, the aircraft-level FHA that has been developed.

F.2.1 Assignment of failure probability.
The failure probability ranking for the fleet combines the maintenance and degradation data previously generated (Tasks Two and Four, respectively) and an assigned simplified numeric value. The failure ranking from this will be combined with the failure severity generated in Task One.

F.2.2 Maintenance data numeric assignment.
Table F-I is an example stratification used to determine the impact of the maintenance data on the risk assessment.

TABLE F-I. Maintenance action category assignment.

MAINTENANCE CATEGORY	DESCRIPTION
1	The occurrence of maintenance actions is very common and component replacement is regularly required on much of the fleet.
2	Maintenance is often required and is necessary on most of the fleet.
3	Limited maintenance is necessary throughout the entire fleet.
4	Maintenance actions have been performed on this device and are limited to a small part of the overall fleet.
5	Limited maintenance actions have been performed on this device but remain an unlikely occurrence.
6	No maintenance actions have been performed on this or similar devices.

The separation between the maintenance category levels is platform dependent. The maintenance actions can be averaged per aircraft per year to provide a comparison of the results and maintenance actions between fleets.

Caution should be taken not to associate automatically the maintenance actions of the worst device/component with the most severe maintenance category as this may unnecessarily highlight an area or device. If possible, the maintenance actions of failure rates should be compared to the same or similar devices on similar platforms.

F.2.3 Degradation assessment numeric assignment.
Similar to the maintenance data partitioning, the degradation assessment generated in Task Four should be converted to a degradation category. Table F-II depicts an example partitioning of the degradation results for components both with and without degradation models.

TABLE F-II. Degradation forecast numerical assignment.

DEGRADATION CATEGORY	DESCRIPTION WHEN USED WITH COMPONENT DEGRADATION MODEL	DESCRIPTION WHEN USED WITH "PASS/FAIL" DEGRADATION CRITERIA
1	The devices are at end of life.	The components have reached end of life.
2	The equipment is showing severe degradation. Remaining in-service life is limited. Attrition of existing equipment replacement has begun.	
3	The equipment is degrading. Continued equipment use may lead to wear-out near next depot-level maintenance cycle.	
4	The equipment is showing some degradation. Wear-out is not likely to occur by next depot-level maintenance cycle.	The components are still functioning within specification.
5	Equipment is in good condition. Only marginal signs of performance degradation.	
6	The equipment is like new. No signs of degradation.	

It is recommended the degradation categories associated with these components be limited to two values: 1 and 4, for components which had only a "pass/fail" degradation analysis criteria unless additional information can be gathered.

F.2.4 Degradation forecast.
Similar to the degradation assessment assignment above, the assignments should also be made for future intervals, if possible. An example of the degradation forecasting intervals can be seen in table F-III. This table depicts the forecast using the degradation analysis on wire taken from three aircraft zones and a set of circuit breakers.

TABLE F-III. Example degradation forecast for three example devices.

DEVICE TYPE	DEGRADATION CATEGORY		
	CURRENT	5-YEAR FORECAST	10-YEAR FORECAST
Leading Edge Wiring	3	3	2
Trailing Edge Wiring	3	2	2
Flight Deck Wiring	5	5	5
DC Circuit Breakers	4	4	3

In this example, the continued equipment use will lead to degradation of the more exposed wire in the leading and trailing edge of the wing. The forecast indicated the trailing edge will start to experience age-related failures of the equipment after 5 years of service. This forecast may impact subsequent plans for replacement scheduling and the development of directed maintenance inspection actions (Task Six).

Depending on the degradation methods for particular components (or the platform needs) this information can also be presented utilizing flight hours. In that case, the "5-Year Forecast" and "10-year Forecast" in table F-III would be replaced with flight hour levels that best represent the use of the fleet.

F.2.5 Combine degradation assessment with maintenance data.
The risk assessment reporting may be reported using the maintenance data and degradation data independently or by combining the two into a single value. This may be done as a summary of the system risk or in the case that there are conflicting failure probability projections between the maintenance and degradation data.

Table F-IV provides a lookup chart for combining the degradation categorization of component with the maintenance assessment.

TABLE F-IV. Degradation assessment categories combined with maintenance data analysis categories.

MAINTENANCE CATEGORY	DEGRADATION CATEGORY					
	1	2	3	4	5	6
1	1	1	1	1	1	1
2	1	2	2	2	2	2
3	1	2	3	3	3	3
4	1	2	3	4	4	4
5	1	2	3	4	5	5
6	1	2	3	4	5	6

The results of combining the maintenance categories with the degradation categories may indicate that component maintenance is more of an issue than indicated by the degradation assessment; this can impact the component degradation forecast results. For example, in table F-III, the DC circuit breakers showed a value of "4" for the current degradation category and were forecast to show no degradation until year 10. But if the maintenance actions associated with the circuit breakers had a maintenance category of “3”, a disparity between the maintenance and degradation values of “1” should revise the forecasted value and reduce the “10-year forecast” to “2”.

F.3 Failure severity.

The failure severity information for the assessment should come from the work performed in Task One. The physical inspection performed in Task Three should be reviewed to determine if the system assumptions made in Task One were accurate. If changes are necessary (e.g., shorter separation distances, lack of physical protection, different routing) the system data used in Task One should be updated and the failure severity reassessed. After review and, if necessary, update of the assessment, the results should include physical EWIS failure assessment and the functional failure assessment (both aircraft-level effects).

The results of the failure probability index for the equipment from section 4 and Task One can be combined to form a risk index based upon the guidance of MIL-STD-882. Table F-V depicts the risk assessment matrix.

TABLE F-V. Risk assessment matrix.

PROBABILITY	SEVERITY			
	Catastrophic (1)	Critical (2)	Marginal (3)	Negligible (4)
Frequent (1)	High	High	Serious	Medium
Probable (2)	High	High	Serious	Medium
Occasional (3)	High	Serious	Medium	Low
Remote (4)	Serious	Medium	Medium	Low
Improbable (5)	Medium	Medium	Medium	Low
Eliminated (6)	Eliminated			

This assessment can be generated and applied to the individual EWIS device level, wiring harness, system, and/or aircraft level. It may be possible to identify the sources for system risk if this assessment is performed at each of these levels. For example, the risk assessment may show a high risk value for the landing gear system. Upon examination, the source of the high failure probability was the system wiring routed in the wheel well. The action plans developed in Task Six can be directed to the source of issues by identifying the source of risk in the system.

F.4 Assessment of mitigation.

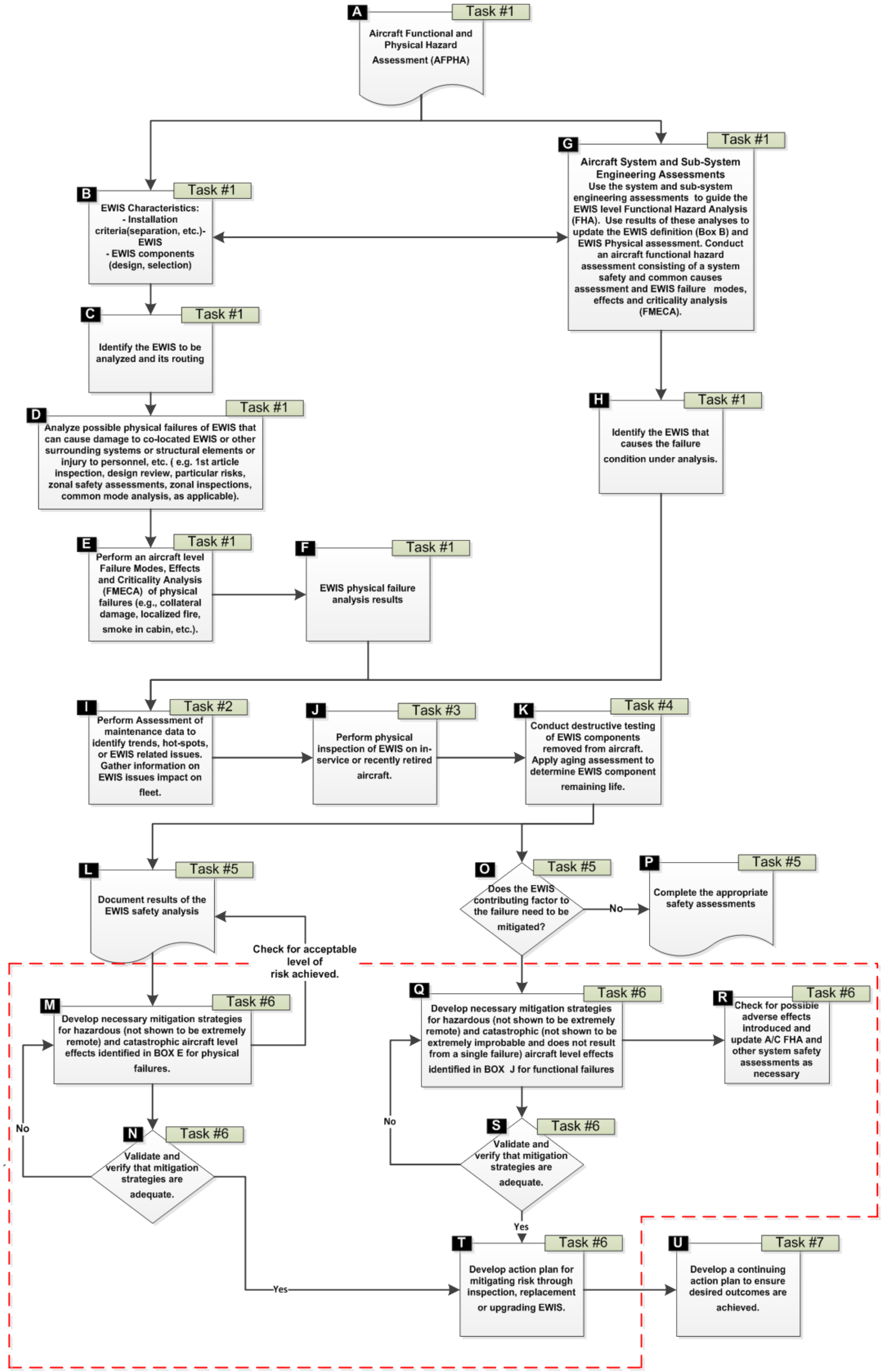
Box O: Contributing factor mitigation (figure F-1): Use the analyses to determine if the EWIS associated with the system under analysis can contribute (in whole or in part) to the failure condition under study. Determine whether the EWIS failure needs to be mitigated. If so, develop, validate, and verify a mitigation strategy (Task Six). Complete the appropriate safety assessment if no mitigation is needed.

APPENDIX G

EWIS TASK SIX – ACTION PLAN

G.1 SCOPE.

Once the EWIS risk assessment is completed (Task Five), actions must be taken to address those zones and components which pose a risk to aircraft airworthiness. This task centers on the actions that can be taken to address identified issues. The integration of the Task Six workflow is shown on figure G-1. The guidance provided in this appendix is based on the information provided in AC 25.1701-1, AC 120-97A, and MIL-STD-882.



NOTE: The red-dashed boxed area includes Task Six efforts.

FIGURE G-1. Risk assessment process flow.

G.2 Determination of actions to be taken.

The actions selected for implementation are dependent upon multiple factors including project, platform, engineering, and risk tolerance constraints. The selection of a mitigation strategy must consider each of these. The following sections highlight some available methods to address the risks identified during the assessment.

G.2.1 Design changes.

Boxes M & N: Development and validation of physical failure mitigation strategies (figure G-1): Components or harnesses that create unacceptably high failure severity values may need to be considered for design changes (e.g., a high-current wiring harness routed too close to a hydraulic line). Identify and develop a mitigation strategy for those components deemed to have too high a risk index if the failure severity was associated with physical failure identified in Boxes E and F.

If a redesign or component changes are considered, the risk assessment for the affected components should be re-evaluated with different solutions to determine how the risk reduction will have different impacts on the system. Validation and verification of the mitigation solution should ensure that:

1. Hazardous failure conditions are extremely remote;
2. Catastrophic failure conditions are extremely improbable and do not result from a single common cause event or failure; and
3. This mitigation solution does not introduce any new potential failure conditions.

G.2.2 Reduction of physical failure risk.

A reduction in physical failure risk can be achieved by implementation of one or more strategies. Methods to reduce physical failure risk include but are not limited to:

1. Physical separation: The wiring may be rerouted or separated from the wiring harness in instances where the critical or redundant systems are routed in the same harness or connector. Increasing the physical separation between the harnesses could reduce the likelihood of arcing damage in collocated harnesses.
2. Segregation: The use of segregation materials may be employed where physical separation is not possible or practical. These physical barriers (e.g., harness sleeving) can limit the area affected by an electrical failure.
3. Limit the fault current: A large factor in EWIS failure is the current available during a fault. Limiting the fault current in the circuit (the electrical current available at the fault location—in a single phase fault this is quantified as the short circuit current at the location) can reduce the potential damage to other wires in the harness, damage to nearby components, and fire ignition.
4. Change circuit protection devices: Standard thermal circuit protection devices are not adequate to prevent damage from electrical arcing events. Circuit protection devices such as arc fault circuit breakers or solid state power systems can limit the energy released in electrical arcing failure.
5. Change wire type: No wire type can fully eliminate damage from electrical arcing; some are better at reducing the damage level.

The damage assessment and associated risk should be reexamined following the selection of a mitigation strategy. This process can be performed multiple times or until an acceptable level of risk has been achieved.

G.2.3 Reduction of functional failure risk.
Boxes Q & S: Development and validation of functional failure mitigation strategies (figure G-1): Identify and develop mitigation strategies for those components with a high functional failure severity. For EWIS components associated with hazardous or catastrophic events, these events should be shown to be improbable and not the result of a single failure, with the aircraft-level effects identified for functional failures.

Once mitigation plans have been developed, the validation and verification of the mitigation solution should ensure:

1. Hazardous failure conditions are extremely remote;
2. Catastrophic failure conditions are extremely improbable and do not result from a single common cause event or failure; and
3. This mitigation solution does not introduce any new potential failure conditions.

G.2.4 Replacement.
If design changes are not possible or an acceptable level of risk has not been achieved, then replacement should be considered for EWIS components that have reached end of life criteria, may soon experience performance degradation, or to achieve risk targets. The need for replacement is based on the individual platform needs and constraints.

G.2.5 Forecasting replacement.
The results of the component degradation assessment performed in Task Four provide a means to forecast EWIS reliability. The benefit of this is that degrading components can be scheduled for replacement in advance. EWIS components that are not in an immediate need for replacement and are not projected to impact aircraft safety or reliability can be scheduled for future maintenance cycles.

G.2.6 Maintenance changes.
The risk assessment identifies safety-critical EWIS components and correlates them with aging and maintenance hot-spots. This information, combined with the aircraft zone breakdown and inspection checklist developed, provides a framework to generate or augment an existing EWIS inspection program. Maintenance efforts can be directed to:

a. Monitor components that are exhibiting deterioration through periodic inspection. Corrective actions can be taken more quickly if failures occur sooner and in higher numbers than predicted by the degradation models.
b. Monitor maintenance hot-spot areas.

The worksheets completed during Task One provide some guidance on how to build an EWIS scheduled inspection plan. The zonal breakdown and analysis should be supplemented with the risk assessment results if additional details would be beneficial for the maintenance program. The inspection checklist and lessons learned in Task Three provide a basis for the development of periodic inspection tasks. The development of these tasks is described in section G.2.

G.3 EWIS Enhanced Zonal Analysis Program Development.
Figures G-2 and G-3 and the narratives on the following pages describe the Enhanced Zonal Analysis Procedures (EZAP) process. The development of EZAP should be performed by those familiar with the risk assessment process. The process below is provided for general information and reflects a process originally designed for commercial aircraft but has been tailored for better applicability to military aircraft.

The objective is to improve maintenance and inspection programs for all EWIS installed on aircraft. Applying the information and lessons learned from the EWIS risk assessment will improve the likelihood that EWIS degradation from many causes, including environmental, maintenance-related, and age-related problems will be identified and corrected. In addition, this information has been reviewed to ensure maintenance actions, such as inspection, repair, overhaul, replacement of parts, and preservation, do not:

a. Cause a loss of EWIS function,
b. Cause an increase in the potential for smoke and fire in the aircraft, or
c. Inhibit safe operation of the aircraft.

The inspection program should be scheduled at regular intervals based on system criticality, maintenance information, and normally scheduled maintenance actions. The results should generate inspection intervals such that areas exposed to harsher environmental and maintenance conditions are checked more regularly than benign areas.

G.3.1 Enhanced Zonal Analysis Procedure.
The EZAP will allow the user to determine the appropriate general or detailed inspections and any cleaning tasks (also referred to as restoration tasks by some manufacturers) needed to minimize the presence of combustible material. An EZAP can be used to develop new wiring cleaning and inspection tasks for both zonal and non-zonal inspection programs.

Use of this procedure to develop a maintenance program will help ensure proper attention is given to EWIS components during maintenance. The EZAP provides a logical procedure for selection of inspections (either general or detailed) and other tasks to minimize combustibles and identify EWIS degradation. An EZAP will identify new wiring inspection tasks for aircraft without a structured zonal inspection program.

G.3.2 Guidance for a General Visual Inspection.
This clarifies the definition of a GVI and provides guidance on what is expected from such an inspection, whether performed as a stand-alone GVI or as part of a zonal inspection.

G.3.3 Protections and cautions.
Guidance is developed for actions and cautionary statements to be added to maintenance instructions for the protection of wire and wire configurations. Maintenance personnel will use these enhanced procedures to minimize contamination and accidental damage to EWIS while working on aircraft.

G.3.4 "Protect and Clean as You Go" philosophy.
This philosophy is applied to aircraft wiring through inclusion in its operators' maintenance and training programs, and stresses the importance of protective measures when working on or around EWIS components. It stresses how important it is to protect EWIS during structural repairs, modifications, or other alterations by making sure metal shavings, debris, and contamination resulting from such work are removed. The "Protect and Clean as You Go" philosophy is translated into specifics by the protection and caution recommendations.

G.3.5 Consolidation with fuel tank requirements.
Fuel tank systems contain EWIS that may be routed independently or integrated with other aircraft systems' EWIS. Aircraft fuel system documents typically address EWIS fuel tank safety, maintenance, and inspection; and should be followed accordingly. If no guidance is available, use FAA AC 120-97 to develop guidelines for proper EWIS fuel tank design and installation, maintenance practices, and inspection protocols.

G.3.6 Enhanced Zonal Analysis Procedure—general guidance.
Current approaches to aircraft wiring and systems platform maintenance will need to be redefined and altered to realize fully the objectives of the EWIS risk assessment. This redefinition must reach both overall philosophy and specific maintenance tasks. This may require more than simply updating maintenance manuals and work cards and improving training. Maintenance personnel need to be aware that aircraft EWIS must be maintained in an airworthy condition. They also need to recognize that visual inspection of wiring has inherent limitations. Small defects such as breached or cracked insulation, especially in small-gage wire, may not always be apparent. Therefore, effective wiring maintenance combines good visual inspection techniques with improved wiring maintenance practices and training.

An EZAP will result in safety improvements for aircraft operated with a maintenance or inspection program that includes a zonal inspection program (ZIP). It is unlikely that ZIPs developed in the past considered wire or other EWIS components, except for the most obvious damage that could be detected by a GVI.

The EZAP logic is likely to identify a large number of EWIS-related tasks that will need to be consolidated into the existing systems maintenance or inspection program for platforms without a ZIP. Those without a ZIP may find it worthwhile to develop a ZIP in accordance with an industry-accepted method in conjunction with an EZAP.

When the EZAP is performed, evaluate items such as plumbing, ducting, control cables, and other system installations located in the zone for possible contributions to wiring or other EWIS component degradation or failures. The results of the analysis will indicate whether a restoration task, a zonal GVI, a stand-alone GVI, or a DET inspection is required to inspect the EWIS in the zone. The type of inspection is determined by completion of EZAP worksheets.

New tasks identified by the EZAP logic should be compared against existing tasks in the maintenance program to ensure they are compatible with each other. Also, existing maintenance task type and frequency should not affect the outcome of the EZAP analysis. The analysis for a particular zone should be completed to identify appropriate EWIS tasks and their frequency. After the analysis is complete, these new EWIS tasks should be compared to existing maintenance program tasks to assess where the new tasks and the existing maintenance program tasks can be logically combined. The EZAP analysis should not be "tweaked" to make the tasks and intervals fit the existing maintenance program just for the sake of tasks alignment.

Platforms may want to use the EZAP logic to identify additional inspection and cleaning tasks for any design changes on their aircraft for which EZAP ICA are not available. An original EWIS ICA developed by a manufacturer (if it exists) may not have taken into account modifications made to the platform by someone other than the OEM.

Each step in the EZAP logic is explained in G.3.6.1 through G.3.6.11. Performers of the EZAP analysis should use the information gathered from the tasks performed during the EWIS assessment on a "representative aircraft". Whenever possible, verify the results of the analysis through use of an actual aircraft (typical aircraft that has not been cleaned) to ensure the inspectors fully understand the zones being analyzed. When the information from the onsite inspection is combined with the risk assessment information, a basis to make determinations on zone density, size, environmental issues, and failure consequence for each zone results.

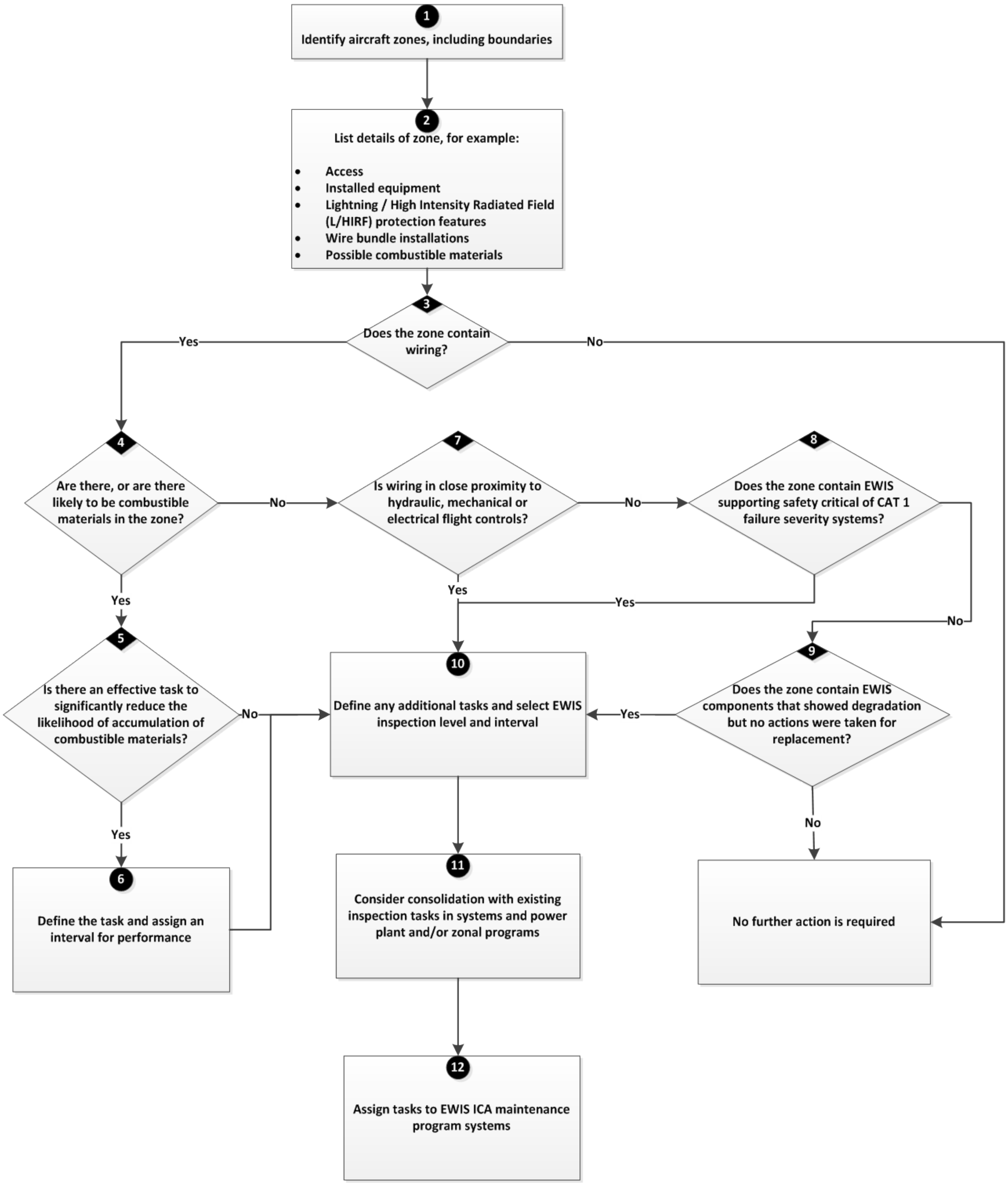


FIGURE G-2. EZAP process.

G.3.6.1 STEP 1: Identify aircraft zones, including boundaries.
The boundaries used for development of the EZAP should be the same, or similar to, those used in the assessment of Task One and Task Three. Where possible, these zones should be defined by actual physical boundaries such as wing spars, major bulkheads, cabin floor, control surface boundaries, skin, etc., and include access provisions for each zone.

G.3.6.2 STEP 2: List details of zone.
Within the zone, identify system installations, significant components, lightning and high intensity radiated field (L/HIRF) protection features, typical power levels in any installed wiring bundles, combustible materials (present or with the potential for accumulation) and any other features that may affect wiring integrity or accumulation of combustibles.

With respect to power levels, the physical damage analysis completed in Task One should be used as a basis to determine the potential physical effects of deterioration.

Identify any locations where both primary and back-up flight controls are routed in close proximity. This information is required to answer the question in STEP 7.

G.3.6.3 STEP 3: Does zone contain wiring?
This question eliminates from the EZAP those zones that do not contain wiring.

G.3.6.4 STEP 4: Are there, or are there likely to be, combustible materials in zone?
This question requires evaluation of whether the zone might contain combustible material that could cause a fire to be sustained in the event an ignition source arises in adjacent wiring. Examples include the presence of fuel vapors, conductive water-based fluids, dust/lint accumulation, and contaminated or flammable insulation blankets.

a. With respect to commonly used liquids (e.g., oils, hydraulic fluids, corrosion prevention compounds), refer to the product specification to assess potential for combustibility. The product may be readily combustible only in vapor mist form. If so, an assessment is required to determine if conditions might exist in the zone for the product to be in this state.
b. Liquid contamination of wiring by most synthetic oil and hydraulic fluids (e.g., Skydrol®) may not be considered combustible. It is a concern, however, if it occurs in a zone where dust and lint are present because wet or oily surfaces attract dust and lint.
c. Avionics and instruments located in the flight compartment and equipment bays tend to attract dust, dirt, and other contamination. Because of the heat generated by these components and their relatively tightly-packed installations, these zones have the potential for accumulation of combustible material. Forced-air ventilation is often used in these areas, which causes lint and dust to be blown about the area and often results in a buildup of dust and lint on component surfaces. Always use the EZAP logic for these zones. The answer to the question in this STEP 4 should be, “YES” for flight compartment and equipment bays.

Although moisture (whether clean water or otherwise) is not combustible, its presence on EWIS components increases the probability of electrical conduction and arcing from small breaches in the insulation. This could cause a localized fire in the wire bundle. The fire could spread if there are combustibles in close proximity. The risk of a sustained fire caused by EWIS failure is considered in the aircraft-level assessment in Task One. This information can be used here to supplement the effects of failure.

G.3.6.5 STEP 5: Is there an effective task to reduce significantly the likelihood of accumulation of combustible materials?
Many maintenance programs do not include tasks directed toward removal of combustible materials from wiring or adjacent areas or prevention of their accumulation. Evaluate whether accumulation on or adjacent to wiring can be significantly reduced.

Though restoration tasks such as cleaning are the most likely applicable tasks, the possibility of identifying other tasks is not eliminated. For example, a detailed inspection of a hydraulic pipe might be appropriate if high-pressure mist from pinhole corrosion could impinge a wire bundle and the inherent zone ventilation is low. Task effectiveness criteria should include consideration of the potential for damage to wiring.

G.3.6.6 STEP 6: Define the task and assign an interval for its performance.
This step will define an EWIS ICA task to reduce accumulation of combustible materials and an effective interval for performance of that task. The defined task should be included as a dedicated task in the systems & power plant section of the maintenance program. It may be introduced within Maintenance Review Board Reports (MRBRs) under the standard practices section (ATA chapter 20 of the MRBR) with no failure effect category assigned.

Restoration tasks should not be so aggressive that they damage wiring but should be performed at a level that significantly reduces the likelihood of combustion.

For fuel system EWIS components, critical design configuration control limitations (CDCCL), inspections, or other procedures must be established, as necessary, to prevent development of ignition sources within the fuel tank system to prevent increasing the flammability exposure of the tanks above the permitted level, and to prevent degradation of the performance and reliability of any means. Visible means to identify critical features of the design must be available in areas of the aircraft where foreseeable maintenance actions, repairs, or alterations may compromise the CDCCL (e.g., color-coding of wire to identify separation limitation). These visible means must also be identified as CDCCL.

G.3.6.7 STEP 7: Is wiring close to both primary and backup hydraulic, mechanical, or electrical flight controls?
This question is asked to ensure STEP 10 logic is applied where wiring is in close proximity to both primary and backup hydraulic, mechanical, or electrical flight controls, even in the absence of combustible materials in the zone.

Proximity is addressed in the inspection-level definition portion of STEP 10 and this question need not be asked for zones where combustible materials are present (as determined in STEP 4),

This step addresses the concern that segregation between primary and back-up flight controls may not have been consistently achieved. Even in the absence of combustible material, a localized EWIS failure could prevent continued safe flight and landing if hydraulic pipes, mechanical cables, or wiring for fly-by-wire controls are routed in close proximity to a wiring harness. In consideration of the redundancy in flight control systems, this question should be answered “YES” if both the primary and back-up system might be affected by wire arcing.

On all aircraft type designs, regardless of design date, alterations performed by TAA or a field-approved repair or alteration may not have taken into account the aircraft’s design specification criteria. It is recommended that the TAA assess whether their design changes route wires within 2 inches or 50 mm of both primary and back-up hydraulic, mechanical, or electrical flight control cables and lines. Similarly, air carriers and air operators should assess any field-approved repairs or alterations or other modifications that have been made to their aircraft to identify any added or altered wiring that may be close to flight control cable and lines.

G.3.6.8 STEP 8: Does the zone contain EWIS supporting safety-critical CAT 1 failure severity systems?
CAT 1 critical systems, circuits, and devices identified in Task One of this assessment (see Severity Categories identified in table B-IX) provide the information to determine where these can be found. The inspection tasks should include information on the system and the EWIS components to be checked within the zone.

G.3.6.9 STEP 9: Does the zone contain EWIS components that showed degradation but no actions were taken for replacement?
The EWIS components identified in Task Four which show degradation but are not selected for replacement (Task Six) should be periodically inspected to identify and preempt the onset of further degradation.

G.3.6.10 STEP 10: Select wiring inspection level and interval.

G.3.6.10.1 Inspection level.
At this point in the analysis, confirmation exisits that wiring is installed in a zone where the presence of combustible materials is possible, in close proximity to primary and backup hydraulic or mechanical flight controls, a CAT 1 component, and/or degradation has been identified. Therefore, some level of inspection of the wiring in the zone is required. This step details how to select the proper level of inspection and interval.

The proper inspection level and interval can be selected through use of ratings tables which rate characteristics of the zone and how the wiring is affected by, or can affect, those attributes. Each platform will determine the precise format of such a rating table, but example rating tables appear on figure G-3. Inspection-level characteristics which may be included in the rating system are identified in G.3.6.10.1.1 through G.3.6.10.1.4.

G.3.6.10.1.1 Zone identification.
According to ATA Specification iSpec 2200, “Manufacturer’s Technical Data,” zones are identified by the aircraft manufacturer “to facilitate maintenance, planning, preparation of job instructions, location of work areas and components, and a common basis for various maintenance tasks.” iSpec 2200 contains guidelines to determine aircraft zones and their numbering. The EZAP process uses these manufacturer-identified zones. The zones are not created uniquely for EZAP.

G.3.6.10.1.2 Zone size.
Zone size determination is based on a comparison of all the zones in a given aircraft model and assessing them in relation to each other. For the purposes of the EZAP analysis, zone sizes are identified as “small”, “medium”, or “large”. For example, the aft cargo bay on a large transport category aircraft would be considered a “large” zone, but the radome on the same aircraft would be considered a “small” zone. The smaller and less congested a zone, the more likely it is EWIS degradation will be identified by GVI.

G.3.6.10.1.3 Zone density.
The density of installed equipment, including wiring and other EWIS components, within the zone is assessed in relation to the size of the zone. Zone density is identified as “low”, “medium”, or “high” for the purposes of the EZAP analysis.

Typical factors to consider are: the number of components, their relative closeness to one another, and the complexity of these components (e.g., multiple electrical, mechanical, or hydraulic connections). For example, the electrical and electronics compartment located in the forward nose section below the flight deck of most large transport category aircraft could be considered a “high”-density zone. This is because the relatively small physical area is crowded with avionics equipment and a large number of wires and other EWIS components. An example of a “low””-density zone on some aircraft is the cargo compartment (as defined by the cargo compartment walls and forward and rear bulkheads). Although this is a large zone relative to other zones on the aircraft, it has relatively few systems or EWIS components installed in it.

G.3.6.10.1.4 Failure severity.
This determination should be based on the failure severity assessment performed in Task One. The aircraft-level physical and functional EWIS failures should be considered when the failure severity is assigned. This assessment should include consideration of the potential for loss of multiple functions and the resultant effect on continued safe aircraft operation. The presence of flammable fluids should also be considered, although design features such as shrouds over the fuel line can be considered to mitigate the likelihood the fuel will be a source of fuel for a fire. Base the determination of potential effects of a fire on adjacent wiring and systems on knowledge of what aircraft systems are in the area under analysis (i.e., what is in the zone) and how loss or degradation of these systems could affect safe operation. The rating system developed should take these potential effects into account.

If a zone does not have mitigating design features that would reduce the adverse effects of a fire, then the potential effects of a fire should be rated higher (e.g., “medium” or “high”). Credit for fire mitigation capability can be given to zones which contain a fire detection and suppression system, or a zone that is designated a “fire zone.” Potential effects of a fire in such zones could then possibly be rated at a lower level. Consideration can also be given to whether the fire could be easily detected by crewmembers or passengers and to whether, if there was a fire, it could be extinguished or controlled by available means. Fire can result in severe outcomes, such as wire-to-structure or wire-to-wire shorting and arcing, in areas such as the flight deck, electrical power centers, and those that contain power feeder cables which are subject to chafing if they have flammable materials close by. A fire in these areas could present a high risk to continued safe flight and landing.

Potential effects of fire must also be considered when wiring is in close proximity to both primary and backup flight controls. A GVI alone may not be adequate if a fire caused by failure of the wiring poses a risk to aircraft controllability.

At minimum, all wiring in the zone will require a GVI at a common interval.

The logic for platforms without a ZIP, asks: “Is a GVI of all wiring in the zone at the same interval effective for all wiring in the zone?” This step calls for consideration of whether there are specific items or areas in the zone more vulnerable to damage or contamination than others and thus may warrant a closer or more frequent inspection.

Such a determination could result in selection of a more frequent GVI, a standalone GVI (for operators with a zonal inspection program), or even a DET. The intent is to select a DET of wiring only when it is determined that a GVI will not be adequate. The one who performs the EZAP should avoid unnecessary selection of a DET where a GVI is adequate. Over-use of DET dilutes the effectiveness of the inspection.

The level of inspection required may be influenced by tasks identified in STEP 5 and STEP 6. For example, if a cleaning task is selected in STEP 5 and STEP 6 that will minimize accumulation of combustible materials in the zone, this may justify selecting a GVI instead of a DET for the wiring in the zone.

G.3.6.10.2 Selecting an inspection interval.

A rating system can be used to select an effective inspection interval. The characteristics for wiring to be rated should include:

a. Likelihood of accidental damage, and
b. Environmental factors.

Rating tables should be designed to define increasing inspection frequency based on increasing risk of accidental damage and increasing severity of the local environment within the zone.

The sample "Interval Determination" table on figure G-3's EZAP Worksheet 4 provides a range of intervals from which to choose. The choice of interval should be based on the reasons for specific rating values assigned for "Hostility of Environment" and "Likelihood of Accidental Damage".

As an example, the table provides a range of inspection intervals for a "Hostility of Environment" rating of "3" and a "Likelihood of Accidental Damage" rating of "3". It depicts the inspection should occur as frequently as every "A-check" but the interval could be as long as once every "1C-check". The choice should be based on the reasons a "3" rating was assigned.

a. The importance of likelihood of accidental damage assessment is that the higher the likelihood of accidental damage from multiple sources, the more frequent the inspection task should be. If, on the other hand, all of the factors except one have been rated as a "1", then the inspection interval could be somewhat longer.
b. The choice of the inspection interval should also be based on what type of environment the EWIS is located in and the condition of the EWIS components. Just as with the ratings for likelihood of accidental damage, the more the EWIS is exposed to various harsh environmental conditions, the more frequent the inspection interval should be. The "Hostility of Environment" and "Likelihood of Accidental Damage" should be considered when the inspection task interval is assigned.

G.3.6.10.3 Inspection-level guidance.

The FAA Continuous Airworthiness Maintenance Program (CAMP) outlines the amount of time between aircraft inspections and how often aircraft components need to be inspected, overhauled, or replaced, and includes EWIS components. There are four levels of maintenance checks under FAA FAR Part 91:

1. "A-checks" are performed at around 500 flying hours (FH). This is a routine check, to make sure everything is functioning safely and efficiently. It can usually be completed overnight at an airport gate, and can even be delayed if an aircraft meets certain predetermined conditions.
2. "B-checks" are more extensive than "A-checks", but can also be completed overnight.
3. "C-checks" require aircraft to be docked at a hangar or repair station for detailed inspections. These are generally performed every 12-18 months, depending on the type of aircraft and the manufacturer's specifications.
4. "D-checks" are done approximately every 4 to 5 years, and are the most intensive, time-consuming aircraft inspection. The aircraft needs to have every fastener, nut, wire, hinge, and component inspected, repaired, maintained, or replaced.

“A/B-checks” are considered minor inspections and are usually performed at the operational station. “C/D-checks” are considered major inspections and are usually performed at a Depot facility.

EWIS inspections are best conducted during planned aircraft inspections and should be more detailed at the “C/D-checks”. Military operations have similar inspection intervals with the times based on flight hours and/or calendar times with the details determined by program requirements.

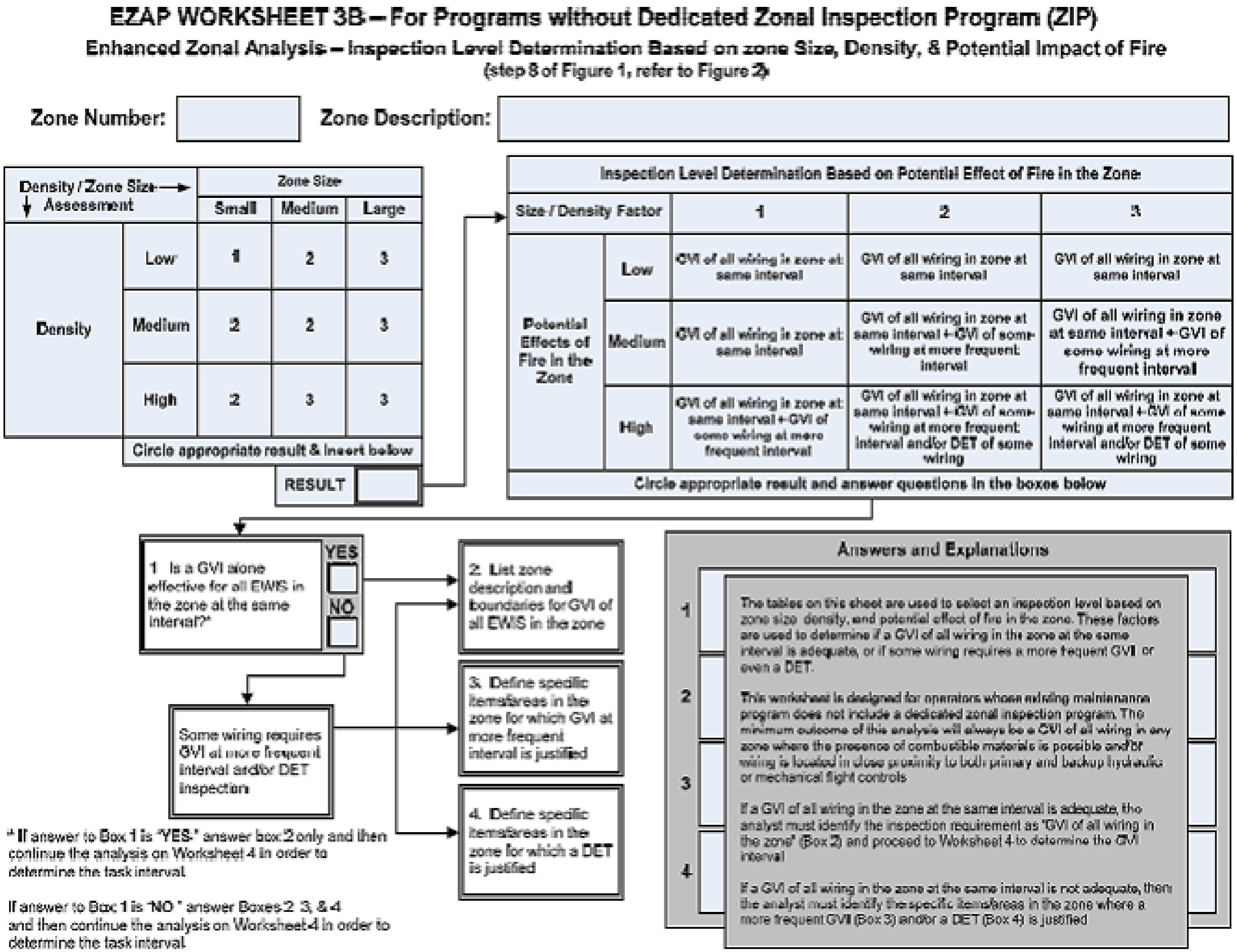
G.3.6.11 STEP 11: Consider consolidation with existing inspection tasks in systems and power plant and/or zonal programs.
This step in the procedure examines the potential for consolidation between the tasks derived from the EZAP and inspections that already exist in the maintenance program. Consolidation would require that the inspections in the existing maintenance program are performed in accordance with the inspection definitions.

Compare new tasks identified by the EZAP logic against existing tasks in the maintenance program to ensure:

1. Tasks are compatible with each other. Existing maintenance tasks and EZAP-generated inspection or maintenance tasks (such as a restoration task) should not compromise or negate each other. For example, an EZAP-generated task should not compromise existing fuel tank system wire maintenance requirements such as separation or configuration specifications.
2. Task intervals are aligned to the maximum extent possible so undue disturbance of EWIS and other systems located within the zone do not occur. However, the inspection interval chosen must ensure the intent and reason for the EWIS inspection is not compromised.
3. Redundant (or duplicate) tasks are consolidated into a single task.
4. Although some non-zonal inspection programs may already include some dedicated inspections of wiring that may be equivalent to new tasks identified by an EZAP, it is expected that a significant number of new wiring inspections will be identified for introduction as dedicated tasks in the system & power plant program. All new tasks identified by an EZAP should be uniquely identified to ensure they are not deleted during future program development.

The following guide can be used to determine proper consolidation between EZAP-derived inspections and existing inspections of the same item or area. When an EZAP task is selected for consolidation, the documentation should include a record identifying it for traceability purposes.

a. If the EZAP inspection interval and existing inspection interval are equal, but the inspection levels are different, the more detailed inspection takes precedence (e.g., a 1C DET takes precedence over a 1C GVI.
b. If the EZAP inspection interval and existing inspection interval are different, but the inspection levels are equal, the more frequent inspection interval takes precedence (e.g., a 1C GVI takes precedence over a 2C GVI).
c. If the EZAP inspection interval and level are different than the existing inspection interval and level, these tasks may be consolidated using the more frequent inspection and at the more detailed level (e.g., a 1C DET takes precedence over a 2C GVI). The tasks should not be consolidated when the more frequent inspection is less detailed.



EZAP WORKSHEET 3B – For Programs without Dedicated Zonal Inspection Program (ZIP)

Enhanced Zonal Analysis – Inspection Level Determination Based on zone Size, Density, & Potential Impact of Fire

(step 8 of Figure 1, refer to Figure 2)

Zone Number: ____ **Zone Description:** ____

Density / Zone Size → ↓ Assessment		Zone Size: Small	Medium	Large
Density	Low	1	2	3
	Medium	2	2	3
	High	2	3	3
	Circle appropriate result & insert below			
	RESULT			

Inspection Level Determination Based on Potential Effect of Fire in the Zone				
Size / Density Factor		1	2	3
Potential Effects of Fire in the Zone	Low	GVI of all wiring in zone at same interval	GVI of all wiring in zone at same interval	GVI of all wiring in zone at same interval
	Medium	GVI of all wiring in zone at same interval	GVI of all wiring in zone at same interval + GVI of some wiring at more frequent interval	GVI of all wiring in zone at same interval + GVI of some wiring at more frequent interval
	High	GVI of all wiring in zone at same interval + GVI of some wiring at more frequent interval	GVI of all wiring in zone at same interval + GVI of some wiring at more frequent interval and/or DET of some wiring	GVI of all wiring in zone at same interval + GVI of some wiring at more frequent interval and/or DET of some wiring
Circle appropriate result and answer questions in the boxes below				

1 Is a GVI alone effective for all EWIS in the zone at the same interval?* YES NO

Some wiring requires GVI at more frequent interval and/or DET inspection

2 List zone description and boundaries for GVI of all EWIS in the zone

3 Define specific items/areas in the zone for which GVI at more frequent interval is justified

4 Define specific items/areas in the zone for which a DET is justified

* If answer to Box 1 is "YES" answer box 2 only and then continue the analysis on Worksheet 4 in order to determine the task interval.

If answer to Box 1 is "NO" answer Boxes 2, 3, & 4 and then continue the analysis on Worksheet 4 in order to determine the task interval.

Answers and Explanations

1
2
3
4

The tables on this sheet are used to select an inspection level based on zone size, density, and potential effect of fire in the zone. These factors are used to determine if a GVI of all wiring in the zone at the same interval is adequate, or if some wiring requires a more frequent GVI or even a DET.

This worksheet is designed for operators whose existing maintenance program does not include a dedicated zonal inspection program. The minimum outcome of this analysis will always be a GVI of all wiring in any zone where the presence of combustible materials is possible and/or wiring is located in close proximity to both primary and backup hydraulic or mechanical flight controls.

If a GVI of all wiring in the zone at the same interval is adequate, the analyst must identify the inspection requirement as "GVI of all wiring in the zone" (Box 2) and proceed to Worksheet 4 to determine the GVI interval.

If a GVI of all wiring in the zone at the same interval is not adequate, then the analyst must identify the specific items/areas in the zone where a more frequent GVI (Box 3) and/or a DET (Box 4) is justified.

FIGURE G-3. EZAP worksheet for dedicated Zonal Inspection Program (ZIP).

EZAP WORKSHEET 4 – Intervals Based on "A" and "C" Checks

Enhanced Zonal Analysis – Interval Determination Based on Hostility of Environment and Likelihood of Accidental Damage
(step 8 of Figure 1, refer to Figure 2)

Zone Number: ______ **Zone Description:** ______

Hostility of Environment	
1 – Passive / 2 – Moderate / 3 - Severe	Enter Number Here
Temperature	
Vibration	
Chemicals (toilet fluids, de-icing fluid, etc)	
Humidity	
Contamination	
Other	
Enter the Highest Number Here →	

Likelihood of Accidental Damage	
1 – Passive / 2 – Moderate / 3 - Severe	Enter Number Here
Ground handling equipment	
Foreign object debris (FOD)	
Weather effects (hail, rain, etc)	
Frequency of maintenance activities	
Fluid spillage	
Passenger Traffic	
Other	
Enter the Highest Number Here →	

Interval Determination		Likelihood of Accidental Damage 1	Likelihood of Accidental Damage 2	Likelihood of Accidental Damage 3
Hostility of Environment	1	4C – 6C 14, 400 - 21,600 FH 60 – 90 M	2C – 4C 7,200 – 14,400 FH 30 – 60 M	1C – 2C 3,600 – 7,200 FH 15 – 30 M
	2	2C – 6C 7,200 – 21,600 FH 30 – 90 M	1C – 4C 3,600 – 14,400 FH 15 – 60 M	A – 1C 450 – 3,600 FH 1 – 15 M
	3	1C – 6C 3,600 – 21,600 FH 15 – 90 M	1C – 4C 3,600 – 14,400 FH 15 – 60 M	A – 1C 450 – 3,600 FH 1 – 15 M

Examples of task interval ranges

RESULT	
Upon completion, enter all task and interval selections onto Worksheet 5, Task Summary	

Interval selection is specific to each task identified on Sheet 3A or 3B. For GVI of entire zone, consider overall zone environment and likelihood of damage. For stand-alone GVI or DET, consider environment and likelihood of damage only in respect to the specific item/area defined for inspection.

NOTE: Interval ranges are quoted in the rating table to explain a typical arrangement of values. For a particular application, these must be compatible with the interval framework used in the existing maintenance or inspection program (as detailed in the current MRB Report). They may be expressed in terms of usage parameter (e.g., flight hours or calendar time) or in terms of letter check.

FIGURE G-3. EZAP worksheet for dedicated Zonal Inspection Program (ZIP) – Continued.

Zonal Task Summary

Zone Number		Zone Description	

Task Summary			
Task #	Access	Task Interval	Task Description

FIGURE G-3. EZAP worksheet for dedicated Zonal Inspection Program (ZIP) – Continued.

APPENDIX H

EWIS TASK SEVEN – ITERATIVE EWIS ASSESSMENT

H.1 SCOPE.

This task objective is for the continuing application of the risk assessment action plan and lessons learned through the aircraft active duty life cycle. This includes tailoring and iterative application necessary in response to changes in platform-specific program direction, and changes to operational requirements such as service life, mission, etc.

H.2 EWIS monitoring.

It is important to track the progress and the fleet-level impacts once Tasks One through Six are completed. To do this, the following actions should be considered.

H.2.1 EWIS component reassessment.

Determine if/when additional fleet inspection and EWIS component comprehensive materials/electrical properties assessment should be performed.

H.2.2 Develop assessment metrics.

The overall goal of the assessment is to improve the aircraft's EWIS. This should be measured and tracked to determine if there has been a noticeable improvement based on the changes implemented from the action plan. The data gathered in Task Two should be used as a baseline to determine improvements in EWIS safety and reliability. Comparisons should be normalized to fleet size and usage to provide a relevant analyses.

H.2.3 Action plan implementation assessment.

Review the action plan that was established and determine the implementation of mitigation strategies, maintenance plans, and other actions defined in Task Six.

H.3 Periodic reassessment.

Continued aircraft use will lead to additional aging and possible degradation of EWIS components. The following are possible circumstances under which additional iterations through the EWIS risk assessment process may be performed.

H.3.1 Change in risk tolerances.

The action plan formed in Task Six is based on project-specific objectives and constraints; over time, these may change. Periodic reassessment will determine if the risk tolerances made in the original assessment are still valid or if changes are needed to satisfy current objectives.

H.3.2 Design life review.

An aircraft EWIS service life extension assessment can be evaluated using this handbook and Task Five; Reassessments should be scheduled prior to projected impact on aircraft airworthiness.

H.3.3 System upgrades.
Upgrade or modification to aircraft systems (such as avionics, hydraulics, etc.) can impact the EWIS risk assessment assumptions. Changes in the electrical loads, routing, and/or separation distance may affect EWIS physical or functional failures on the aircraft during these upgrades or modifications. The proposed changes should be integrated with the EWIS risk assessment model. This would require gathering of EWIS data as outlined in Task One (EWIS documentation), risk assessment performance in Task Five (risk assessment), and the evaluation of risk and mitigation strategy action in Task Six (action plan).

H.3.4 Mission change.
This may include changes in equipment. Furthermore, a change in aircraft mission profile may also impact the risk tolerance. The decisions made on risk mitigation strategies proposed during the original risk assessment effort many need to be re-examined to determine if the actions will be necessary to achieve risk level for the new mission profile.

Custodians:
Army – AV
Navy – AS
Air Force – 11
DLA – CC

Preparing activity:
Air Force – 11
(Project SESS-2013-004)

Review activities:
Army – AR, CR, MI, TE
Navy – EC, OS, SH
Air Force – 19, 70, 71, 84, 85, 99

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above through use of the ASSIST Online database at https://assist.dla.mil.