Joint Interment Testing (JIT) Intermittent Fault Activities

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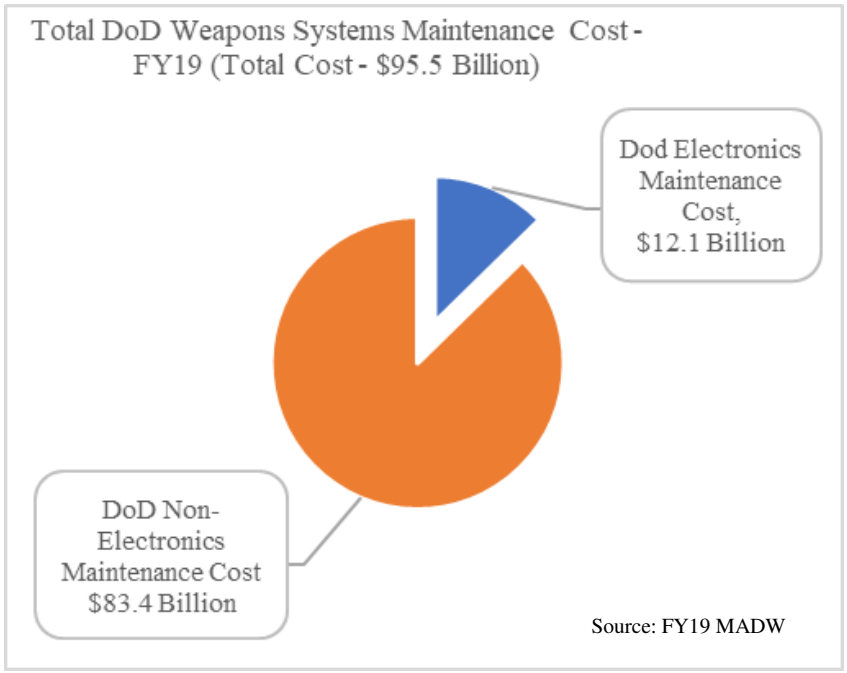
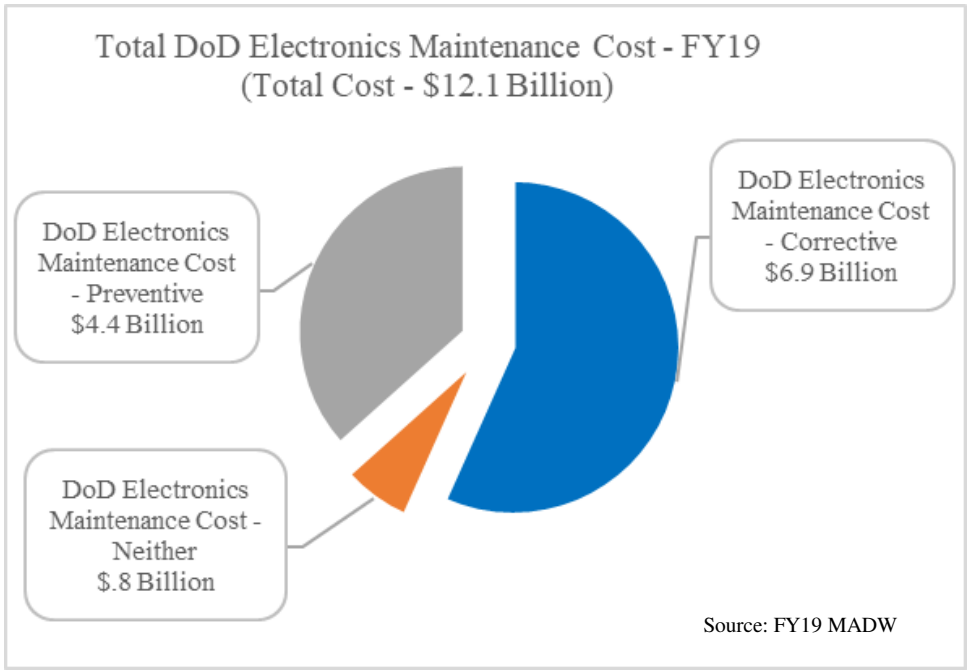
Intermittent Fault Definition

Intermittent faults are short duration impedance variations (opens/shorts) that occur in conductive paths in LRU/WRA chassis/ backplanes or weapon system electrical wiring interconnect systems (EWIS). Intermittent faults occur as a result of various operational environmental stimuli, including, but not limited to, thermal stress, vibrational stress, gravitational G-force loading, moisture and/or contaminant exposure, as well as changes in the material due to age and use, such as the growth of tin whiskers, metal migration and delamination of materials. These faults can occur individually and /or in rapid succession on any chassis or backplane circuit or weapon system EWIS. Fault durations range in time from nanoseconds to milliseconds and have variable impedances. These circuit path disruptions are frequently caused by cracked solder joints; intermittent coax lines (e.g., shield corrosion, damaged center conductor, etc.); broken, cracked or frayed wires; loose clamps; and unsoldered pins. These circuit path disruptions often cause functional failures/faults in LRU/WRA chassis and backplanes or weapon system EWIS whose root cause(s) cannot be detected and isolated using traditional automatic test equipment (ATE) and troubleshooting processes. Lacking the ability to detect and isolate intermittent failures and provide environmental stimuli during test and repair process, such assets are commonly reported as no-fault-found (NFF) or as one of the reported-NFF repair codes (e.g., cannot duplicate (CND), retest OK (RETOK), beyond capability of maintenance (BCM), disassemble-clean-reassemble (DCR), etc.).

Source
MIL-PRF-32516

Intermittent Fault Problem





Intermittent electrical failures continue to be a leading contributor to DoD's $3 billion annual No Fault Found (NFF) problem, unnecessarily consuming 25% of the electronics maintenance budget.

Chartered JIT WG Goals

- Define and validate joint performance requirements for a Joint Service intermittent fault detection system.
- Collect and analyze implementation and operational data on commercial field intermittent fault detection systems in use currently.
- Define the minimum fault detection threshold requirements for the applicable wiring systems, component types, and system architectures.
- Identify, define and validate test methods for ensuring that specified minimum performance requirements for detecting and isolating intermittence are met.
- Publish a joint performance requirements Military-Performance (Mil-PRF) document.
- Brief and publish findings in a technical report and make a recommendation to Service Components on a path forward.

JIT WG Activities

- September 2012 – JIT Chartered
  - Instrumental in shaping the strategic and tactical activities required to identify diagnostic equipment capable of detecting intermittent faults.
  - Developed minimum performance requirements for detecting and isolating intermittence:
- January 2014 - Contract Awarded: Intermittent Fault Emulator (IFE) –
  - NAWCAD, Lakehurst
  - Hill AFB
- March 2015 – Published: MIL-PRF-32516, Electronic Test Equipment, Intermittent Fault Detection and Isolation for Chassis and Backplane Conductive Path
- January 2016 – Intermittent Fault Detection and Isolation Industry Capability Assessment at NAWCAD Lakehurst
- November 2020 - Government/Industry Coordination:
  - Draft MIL-PRF-32516A, Electronic Test, Intermittent Fault Diagnostic Equipment (Electrical)
  - Draft MIL-PRF-32516/1, Intermittent Fault Diagnostic Equipment (Electrical), DEPOT Level
- April 2017 – Published: MIL-HDBK-527, Guidance for Intermittent Fault Emulator (IFE)
- May 2018 – Completed: CTMA Partner meeting to discuss the development of an implementation plan for intermittent fault diagnostic equipment (IFDE).
- August 2918 – Completed evaluation: FRC-East, LP-CRADA, PIFD Technology

JIT WG Activities - continued

- February 2019 – Published: Technical Studies, Analyses for Intermittent Fault Detection Isolation System (IFDIS) Implementation Across DoD, Final Report
- April 2019 – Signed: Office of the Assistant Secretary of Defense Memorandum
- December 2019 – Completed demonstration: Naval Air Station Lemoore Industry Week
- March 2020 - Published (Added Intermittent Fault definition): MIL-HDBK-525 with Change 1, Electrical Wiring Interconnect System (EWIS) Integrity Program
- March 2020 – In process: MIL-HDBK-454B, General Guidelines For Electronic Equipment; Drafted Intermittent Fault Guideline and forwarded to Handbook custodian.
- Monthly Teleconference – Second Tuesday, Government only
- Ongoing Efforts:
  - ❖ Draft MIL-PRF-32516/2, Intermittent Fault Diagnostic Equipment (Electrical), Field Applications
  - ❖ Draft MIL-PRF-32516/3, Electronic Test Equipment, Emulator, Intermittent Fault Detection and Isolation
  - ❖ Congressional Inquiry Response
  - ❖ Follow On - Office of the Assistant Secretary of Defense Memorandum

IFDIS Deployment

USAF IFDIS #1
F-16 Hill AFB
2008

USAF IFDIS #2
F-16 Hill AFB
2009

USAF IFDIS #3
F-16 Hill AFB
2014

Navy IFDIS #1
F/A-18 FRC-SW
2016

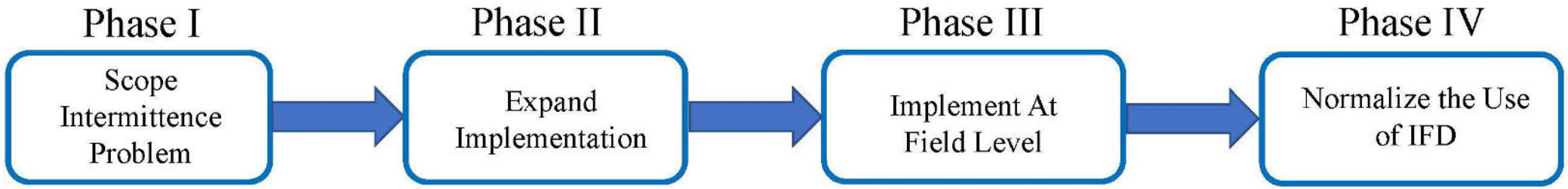
Navy IFDIS #2
F/A-18 FRC-W
2017

Navy IFDIS #3
F/A-18 FRC-MA
2018

Navy IFDIS #4
EA-18G NSWC Crane
2019

F-35 JPO
PFID ATO
2020

Intermittent Fault Implementation Strategy



- Charter JITCBM+ JIT WIPT
- Specify Detection & Isolation System
- Understand Scope Across DoD
- Formalize The Failure Mode (MIL-PRF-32516)
- Develop MADW Algorithm
- Develop A Solution Set
- Develop IFE
- Conduct Industry Days
- Implementing DoD Maintenance Activities

- DoD Depot Maintenance Activities
- Update MIL-PRF-32516
  - EWIS
  - Weapon System
  - Depot
  - Field
  - IFE
- Formalize Military Service Guidance
  - JSWAG
  - MIL-HDBK-454
  - MIL-HDBK-525
  - MIL-HDBK-527
- Establish Centers of Excellence Establishment

- Leverage Phase II Results
- Establish Certification Central Agency
- Expand Centers of Excellence
- Continue to Refine MADW Data
- Increase Adoption of IFD Technology
- Distribute F-35 JPO Results & Cost Savings
- Increase adoption of IFD Solution Set for EWIS

- Expand to All Levels of DoD Maintenance
- Expand to on Weapon System Monitoring
- Expand to Initial Manufacture of Electronic Components
- Collaborate with JSWAG
- Train Workforce

JSWAG
Proposed JIT Committee

The JSWAG JIT Committee provides a forum to advise and assist in the implementation of a DoD intermittent fault detection (IFD) solution. The committee will leverage current and emerging IFD technology for demonstration, testing, and cost-benefit analysis. Actions will include but not be limited to:

- Educate and inform electronics maintenance community on IFD.
- Define and validate joint performance requirements for a Joint Service IFD system.
- Collect and analyze implementation and operational data on IFD systems currently in use.
- Identify, define and validate test methods for ensuring that specified minimum performance requirements for detecting and isolating intermittence are met.
- Leverage DoD's Maintenance and Availability Warehouse to assist in the identification of intermittence related readiness and cost drivers, and recommend IFD opportunities. Investigate and develop plans for integrating IFD with existing EWIS maintenance and repair diagnostics and diagnostic equipment.
- Investigate intermittence-driven EWIS unscheduled maintenance. Develop recommendations and plans for decreasing intermittence-driven unscheduled maintenance and shifting to schedule-based IFD proactive maintenance.
- Collaborate with industry and academia on innovative intermittence-driven NFF solutions and methods.

Backup Slides

Intermittent Fault Emulator

MIL-HDBK-454 Proposed Intermittent Fault Guideline

GUIDELINE TBD

INTERMITTENT FAULT DIAGNOSIS

1. Purpose. This guideline establishes criteria for diagnosing intermittent faults in Electronic Equipment backplane, chassis and wire harness conductive paths.

2. Applicable documents. 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.

MIL-PRF-32516	Electronic Test Equipment, Intermittent Fault Detection and Isolation for Chassis and Backplane Conductive Paths
MIL-STD-810	Environmental Engineering Considerations and Laboratory Tests.

2.1 Definitions.

2.2 Intermittent faults. Intermittent faults are short duration discontinuities (opens/shorts) that occur in conductive paths in Electronic Equipment chassis/ backplanes and wire harnesses. Intermittent faults occur as a result of various operational environmental stimuli, including, but not limited to, thermal stress, vibrational stress, gravitational G-force loading, moisture and/or contaminant exposure, as well as changes in the material due to age and use, such as the growth of tin whiskers, metal migration and delamination of materials. These faults can occur individually and /or in rapid succession on any chassis, backplane circuit or wire harness. Fault durations range in time from nanoseconds to milliseconds and have variable random impedances. These conductive path disruptions are frequently caused by: cracked solder joints; intermittent coax lines (e.g., shield corrosion, damaged center conductor, etc.); broken, cracked or frayed wires/wire harnesses; loose clamps; improper crimp connections and unsoldered pins. These conductive path disruptions often cause functional failures/faults in Electronic Equipment chassis, backplanes and wire harnesses whose root cause(s) cannot be detected and isolated using traditional automatic test equipment (ATE) and troubleshooting processes. Lacking the ability to detect and isolate intermittent failures and provide environmental stimuli during test and repair process, such assets are commonly reported as no-fault-found (NFF) or as one of the quasi-NFF repair codes (e.g., cannot duplicate (CND), retest OK (RETOK), beyond capability of maintenance (BCM), disassemble-clean-reassemble (DCR), etc.).

MIL-HDBK-454 Proposed Intermittent Fault Guideline (continued)

3. General Guidelines.

3.1 General. Each type of Electronic Equipment is different in its function, configuration and operational environment. As a result, no single test method or procedure can adequately replicate an intermittent fault occurrence for all Electronic Equipment. A careful review of the nature of the failure and the operational conditions under which the failure occurred is required. The following steps are recommended when by careful analysis it is determined that the failures occur during ground or flight operating conditions, and the operating temperature does not appear to be contributing to the occurrence of the failures.

3.2 Intermittent faults typical resulting effects.

3.2.1 Vibration-induced. The following is a list of typical effects that may occur as a result of vibration (this list is not intended to be all-inclusive):

a. Chafed wiring.
b. Loose fasteners/components
c. Intermittent electrical contacts
d. Electrical shorts.
e. Deformed seals.
f. Failed components.
g. Optical or mechanical misalignment.
h. Cracked and/or broken structures.
i. Migration of particles and failed components.
j. Particles and failed components lodged in circuitry or mechanisms.
k. Excessive electrical noise.
l. Fretting corrosion in bearings.

3.2.2 Temperature-induced. The following is a list of typical effects as a result of temperature and temperature changes (this list is not intended to be all-inclusive):

a. Binding or slackening of moving parts.

MIL-HDBK-454 Proposed Intermittent Fault Guideline (continued)

b. Deformation or fracture of components.
c. Cracking of surface coatings.
d. Leaking of sealed compartments.
e. Failure of insulation protection.
f. Differential contraction or expansion rates or induced strain rates of dissimilar materials.
g. Intermittent electrical contacts.
h. Electrical shorts/opens.
i. Failed components.
j. Changes in electrical and electronic components.
k. Electronic or mechanical failures due to rapid water or frost formation.
l. Excessive static electricity.

3.2.3 Combined environmental-induced. Temperature, humidity, vibration, and altitude can combine synergistically to produce the following failures. Although altitude is included in the following discussion typically in regard to Electronic Equipment operating environment it mainly impacts cooling and is a function of temperature. Typically Combined Environmental Test facilities do not include altitude test capability. It should be noted that airborne Electronic Equipment may be operated in environments exceeding -55 °C to +120 °C, 40,000 foot altitude and high vibration due to take-off/landing and carrier catapult launches and arrested landings. The following examples are not intended to be comprehensive:

a. Shattering of optical material. (Temperature/Vibration/Altitude)
b. Binding or loosening of moving parts. (Temperature/Vibration)
c. Separation of constituents. (Temperature/Humidity/Vibration/Altitude)
d. Performance degradation in electronic components due to parameter shifts (Temperature/Humidity)
e. Electronic optical (fogging) or mechanical failures due to rapid water or frost formation. (Temperature/Humidity).
f. Differential contraction or expansion of dissimilar materials. (Temperature/Altitude)
g. Deformation or fracture of components. (Temperature/Vibration/Altitude)
h. Cracking of surface coatings. (Temperature/Humidity/ Vibration/Altitude)
i. Leakage of sealed compartments. (Temperature/Vibration//Altitude)
j. Failure due to inadequate heat dissipation. (Temperature/Vibration /Altitude)

MIL-HDBK-454 Proposed Intermittent Fault Guideline (continued)

3.3 Operational environment. A review should be conducted of technical manuals, operating manuals and any available operating environment information, prior to development of test procedures using the tailoring process in MIL-STD-810 to determine where forcing functions of temperature, humidity, vibration, and altitude are foreseen in the Electronic Equipment operational environment. Use this method only if the proper engineering has been performed such that the environmental stresses associated with the individual test methods are considered. If appropriate, tailor Electronic Equipment testing to include storage thermal environments and include in environmental testing or, perform them as separate tests, using the individual test methods. It is recommended that where the operational temperature and vibration test levels are not known that the qualification temperature and vibration levels during troubleshooting of the Electronic Equipment be reduced in order to not over stress the Electronic Equipment. The intent is to subject the Electronic Equipment to temperature/vibration level low/high enough to stimulate the intermittent fault, but not reduce the operational life of the Electronic Equipment.

4. Detail guidelines. Testing for intermittent faults should be conducted using diagnostic equipment meeting the performance requirements of MIL-PRF-32516. The diagnostic equipment covered by this specification is intended for use in detecting and isolating intermittent faults in Electronic Equipment, chassis, backplanes and their wire harnesses. The diagnostic equipment is intended to be used with the Electronic Equipment (with internal subassemblies removed) being stimulated by temperature, vibration or vibration/temperature to emulate the environment in which the fault originally occurred. MIL-PRF-32516, Appendices A through C, provide recommended guidelines for defining this external stimulation.

5. Integrated diagnostics. See guideline 77.

NSWC Crane Ribbon Cutting