Reducing NFF & Improving Operational Availability Through Intermittent Fault Detection

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No Fault Found:

- **ARINC 672 – Guidelines for The Reduction of No Fault Found (NFF)**
  - Emphasis on increased technician training
  - Improved data collections systems and analysis
  - Nothing included in the 672 Guidelines to address technology / diagnostics gaps
  - NFF costs a typical US commercial carrier approximately $250k per year per aircraft
  - NFF cost the Department of Defense (DoD) between $2B - $10B annually

- **Universal Synaptics supports ARINC 672 Guidelines**
  - Over 20 years experience in NFF remediation and solutions
  - Focus on improved diagnostics capability to address intermittent faults in Line Replaceable Units (LRUs) and EWIS which has been conclusively linked as a significant contributor to NFF
  - Research and practical application has demonstrated significant reductions in NFF when all three are applied to the NFF problem
The Problem:

- Aircraft electronic LRUs test “No Fault Found” (NFF) approximately 50% of the time
  - Box malfunctions intermittently during flight, but tests good during subsequent ground testing
  - Intermittent activity also categorized as RTOK, CND, NTF or even “gremlins”
  - Intermittent discontinuity is a growing problem in electronic systems

- Intermittent faults are mechanical in nature
  - Failures are in wiring, solder joints, wire wraps, connectors, via’s etc.
  - Modern components are more reliable and capable – intermittent discontinuity a major concern and cost driver

No Fault Found costs the DoD between $2 and $10 Billion annually
Conventional Approach:

- Functional ATE and Continuity testers cannot detect and isolate intermittent faults that cause NFF
  - Tests only one function at a time
  - Tests only one circuit at a time, even when connected to multiple circuits
  - Digital averaging, scanning and sampling masks / misses the intermittent faults – a testing “blind spot” / “testing void” exists
  - LRUs are not tested in an operational environment where the failures occur
  - Only designed to find functional failures, failed components and “hard” failures (opens circuits / short circuits)
  - The nodal architecture of LRUs prohibits multi-plexing
  - Intermittent faults that cause NFF do not follow specific failure patterns

Conventional Approach = Conventional Results
F-16 LRU Field & Depot NFF:

Source: USAF
BAD ACTORS


• 15 bad actors included in the cost study: USN/USMC spending an estimated the $333.4M on O&S due to issues with intermittent failures

Source: NAVAIR
MX and Supply Impact:

- Tools provided to maintainers are not sufficient:
  - Just because a UUT passes BIT or ATE tests multiple times in a row, does NOT mean there isn’t a failure
  - BIT / ATE testing does not check all circuits simultaneously or functional paths in an LRU or connection paths to SRUs
  - ATE does not test in an operationally relevant environment

- Flightline “Blacklisting” of LRUs makes an expensive supply problem worse
  - Creates availability issues
  - Masks the real problem (undetected intermittence)
  - Recirculates “bad actors” to other military units and commercial carriers, thus perpetuating the problem

An Innovative Solution is Needed to Solve This Problem
Operational Impact:

• High MICAP rates
  – Missions canceled / postponed
  – Readiness is negatively impacted

• High NFF / RTOK / CND rates
  – Wasted I / O / D-level maintenance resources and supply man-hours
  – Wasted time on supply documentation, transportation and troubleshooting

• Supply chain becomes more expensive and less responsive
  – Each LRU sent to the depot for a non-fix, unnecessarily wastes Combat and Support Commands millions of dollars each year!
  – High availability (even a 100% production fill rate) does not equal high reliability or weapon system readiness

The DoD MX Enterprise is large, global, complex and costly. Change is required to reduce NFF & improve operational availability
Intermittent Faults:

• Three Stages to an intermittent fault:

  
  **STAGE-1**
  
  Random
  Low-Level Noise
  Micro-Breaks

  **STAGE-2**
  
  Intermittency

  **STAGE-3**
  
  Hard /
  Semi-Hard
  Traditional
  No Fault Found
  IFDIS & Ncompass-Voyager Detectable
Intermittent Faults, Physical Effects:

- Cracked solder joint
- Broken wire
- Loose crimp connection
- Loose or corroded wire wrap
- Corroded connector contact
- Sprung connector receptacle
- Deteriorated wire insulation
- Hairline crack in printed circuit trace
- Unsoldered connection

Physical Manifestations, Not Electronic Component Failures
Department of Defense Solution:

- Office of the Secretary of Defense established the Joint Intermittence Testing (JIT) Working Integrated Product Team (WIPT) in 2012 – Joint Service effort to address the intermittent testing void


- Two Intermittent Fault Emulators (IFEs) have been delivered to the DoD to “test, test equipment's ability to detect and isolate intermittent faults in compliance with MIL-PRF 32516”

- Universal Synaptics has proven solutions that detect and isolate intermittent faults down to 50ns *TRL 9 technology solutions

- Successful NFF remediation projects with the United States Air Force (USAF), Naval Air Systems Command (NAVAIR) and commercial carriers

One USAF Project Produced a 28 Times Return on Investment (ROI)
Universal Synaptics NFF Solutions:

Ncompass-Voyager™ and the Intermittent Fault Detection & Isolation System™ (IFDIS™)

- Advanced all lines all the time circuit monitoring
- Proven technology that reduces NFF and improves system availability while reducing cost
- TRL 9 solutions

“If we’re going to keep the advantage that we’ve historically had then we need to keep up [technologically].”
– Secretary of Defense Ash Carter
IFDIS & Ncompass-Voyager Proven Results:

- F-16: MLPRF, CADC, Az/EL, Digibus, Antenna & PSP LRUs
- F/A-18: GCU (A-D, E-F Block Aircraft) WRAs
- EA-6B: AIC-45 WRAs
- UH-60: Main Rotor Blade De-Icing Wiring Harness (EWIS)
- ICBM: Wiring Harnesses (EWIS)
- Boeing 757: APU/ECU, TMC LRUs
- Airbus A320: ELAC, BPCU LRUs
- Automotive, Light Rail & Consumer Electronics
Technology Deployment – Clients & Partners:
Technology Recognition:

“Create the Future” Contest – “Top 100 Finalist” 2015

Best of State, Applied Science & Technology Category – Winner 2014


CTMA Symposium, OSD MX Technology Challenge – “Top 5 Finalist” 2012 & 2013
Conclusion:

• Undetected intermittent faults are a systemic issue – an obvious and billion dollar NFF problem exists

• Advanced diagnostic solutions are available to detect and isolate intermittent faults that cause NFF

• Intermittent fault detection and isolation capability has proven to reduce NFF, reduce costs, reduce MICAPs, improve cycle times and improve availability

• IFDIS™ & Voyager™ are proven solutions making a positive impact today

To Solve NFF Our Community Must Focus on Technology Solutions that Address the Billion Dollar Intermittent / NFF Problem
Questions?

Universal Synaptics

Interested in Solving NFF, connect with us

Contact: Ken Anderson - 801.731.8508 – Contact@Usynaptics.com – www.USynaptics.com - @USynaptics
Back-up Slides:

Intermittent Fault Detection & Isolation System (IFDIS)
F-16 MLPRF Fault Isolation Graphic

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F-16 MLPRF Fault Location Picture

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F-16 MLPRF Results

Breakdown of MLPRF Intermittent Circuit Root Causes

- Cracked Solder Joints
- Intermittent Coax Line
- Broken Wire
- Loose Crimp
- Unsoldered Pin

- Intermittent Coax Line, 33%
- Cracked Solder Joint, 34%
- Broken Wire, 20%
- Loose Crimp, 9%
- Unsoldered Pin, 4%

Note: The IFDIS is the only test system that is designed to find and pinpoint these elusive faults that scanning test sets miss.
F-16 MLPRF Results

MLPRF Mean Operating Time Between Depot Repair

<table>
<thead>
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<th>Average Mean Operating Time Between Depot Repair in Hours (for IFDIS Tested Units)</th>
<th>Before IFDIS Testing</th>
<th>After IFDIS Testing</th>
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<tbody>
<tr>
<td>290</td>
<td>Half of the MLPRF Population Has Been IFDIS Tested</td>
<td>926</td>
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MLPRF Availability Tripled!

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## F-16 MLPRF Results

<table>
<thead>
<tr>
<th>Serial Number</th>
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F-16 MLPRF Results

MLPRF IFDIS Testing Investment & Return

- Investment for MLPRF IFDIS Test Capability: $2,200,000
- Savings Due to Reduced Number of MLPRFs Being Depot Repaired: $20,000,000
- Value of MLPRFs Returned to Service as a Direct Result of IFDIS Testing: $42,000,000
- Total Return (to date) From MLPRF IFDIS Testing: $62,000,000

28 times Return on IFDIS Investment!
F/A-18 Hornet

F/A-18 Hornet Generator Convertor Unit (GCU) Weapon Replaceable Assembly (WRA)

- Second highest WRA degrader in the NAVAIR inventory
- Conventional scanning ONE circuit at a time test equipment unable to identify intermittent issues
- IFDIS detected and isolated one or more intermittent circuits in 80% of GCU’s IFDIS tested – ALL GCUs had been certified Ready for Install (RFI) before IFDIS testing
JIT Team Definition of “Environmentally Induced Intermittent Fault”

- A discontinuity that occurs in LRU/WRA chassis and backplane conductive paths 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 tin whiskers, metal migration and delamination of materials. These faults can occur individually and/or in rapid succession on any chassis or backplane circuit.

Intermittent Fault Universe

JIT Team Scope