The Intermittent Testing Void

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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

Increased Training, Improved Data and Advanced Diagnostics

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

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
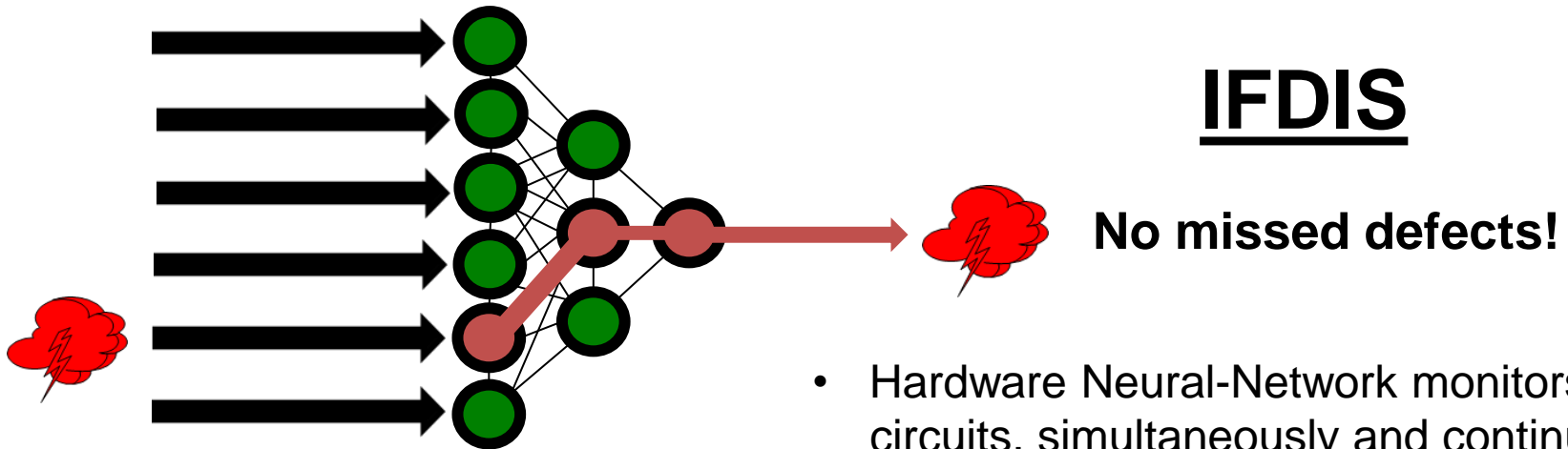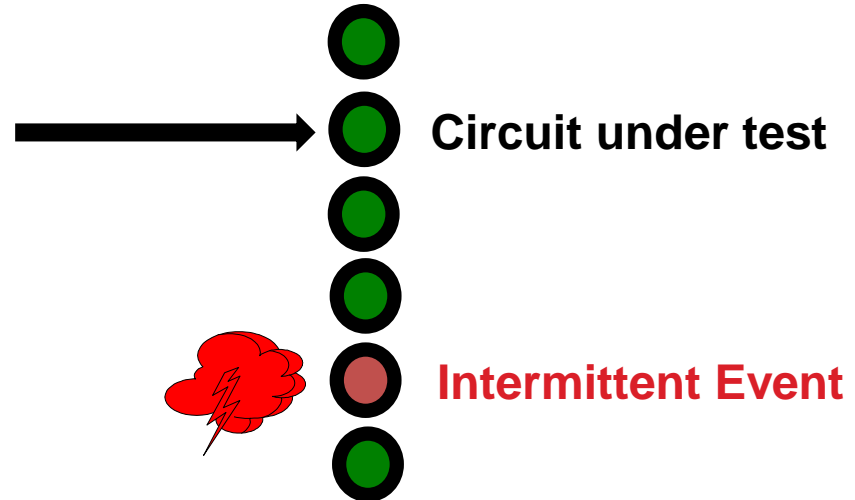
Intermittent Faults:

- Three Stages to an intermittent fault:
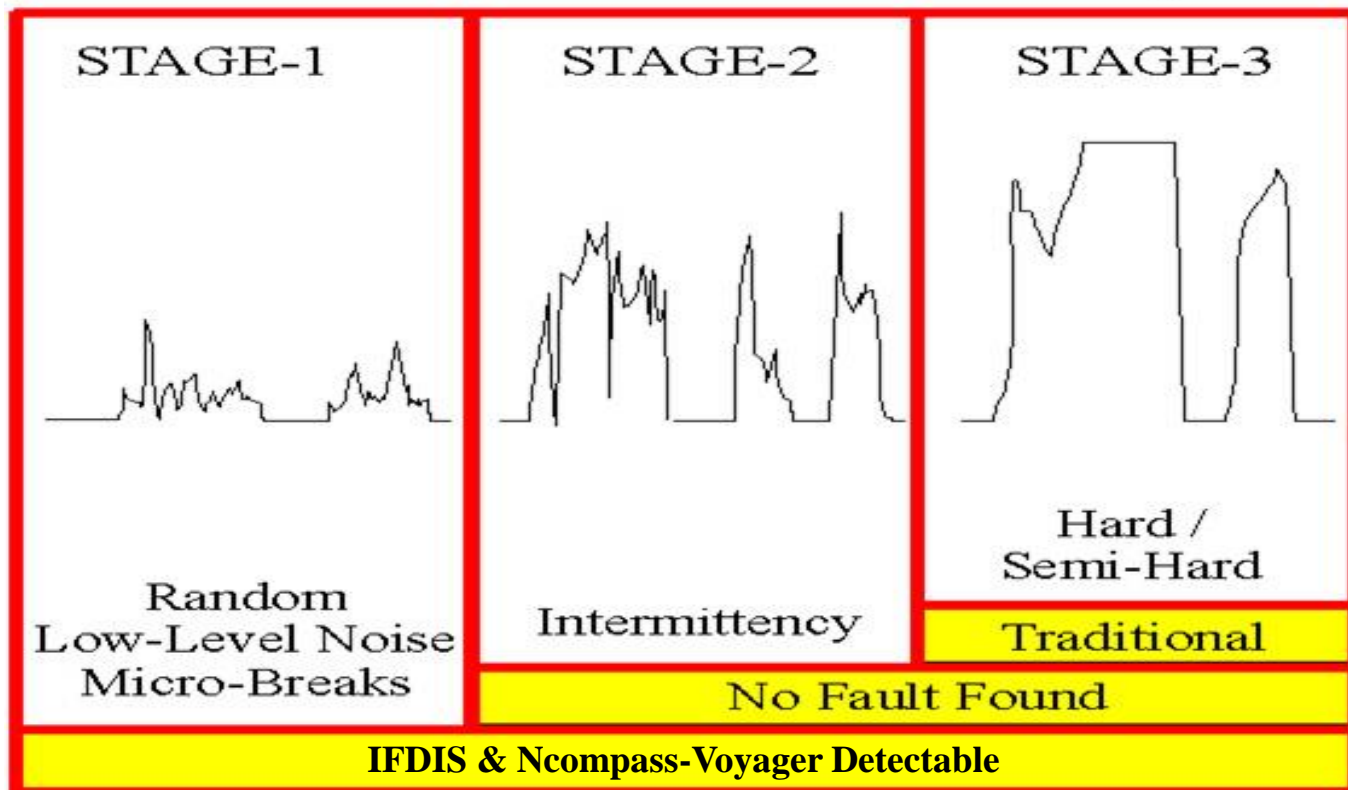
Intermittent Fault Detection Science

Conventional ATE

- Measures only one circuit at a time, even when connected to multiple circuits

- Filters and averages out intermittent events that cause NFF

Circuit under test

Intermittent Event

IFDIS

No missed defects!

- Hardware Neural-Network monitors **ALL** circuits, simultaneously and continuously with high sensitivity

Conventional Tester Probability of Detecting a Random Intermittent Event
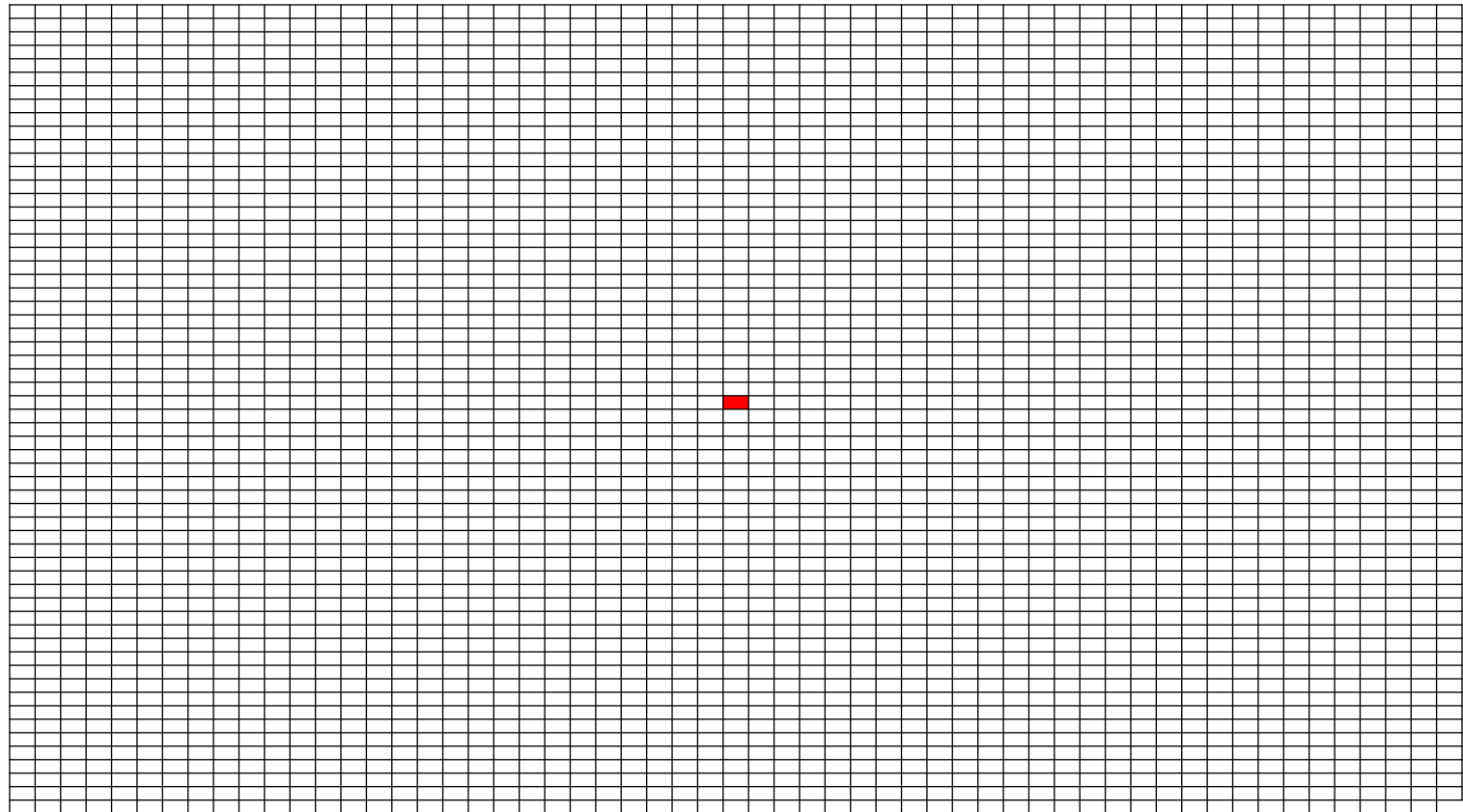
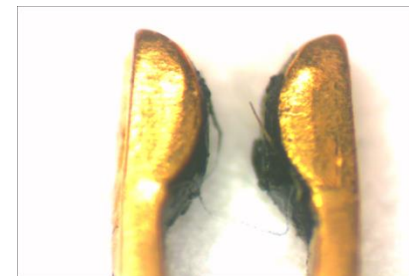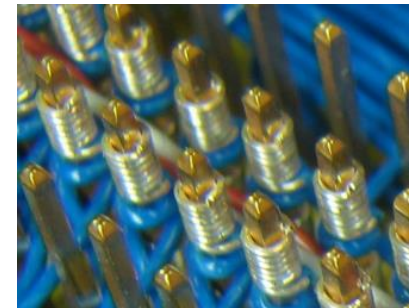

.03% detection probability

IFDIS & Voyager Probability of Detecting a Random Intermittent Event
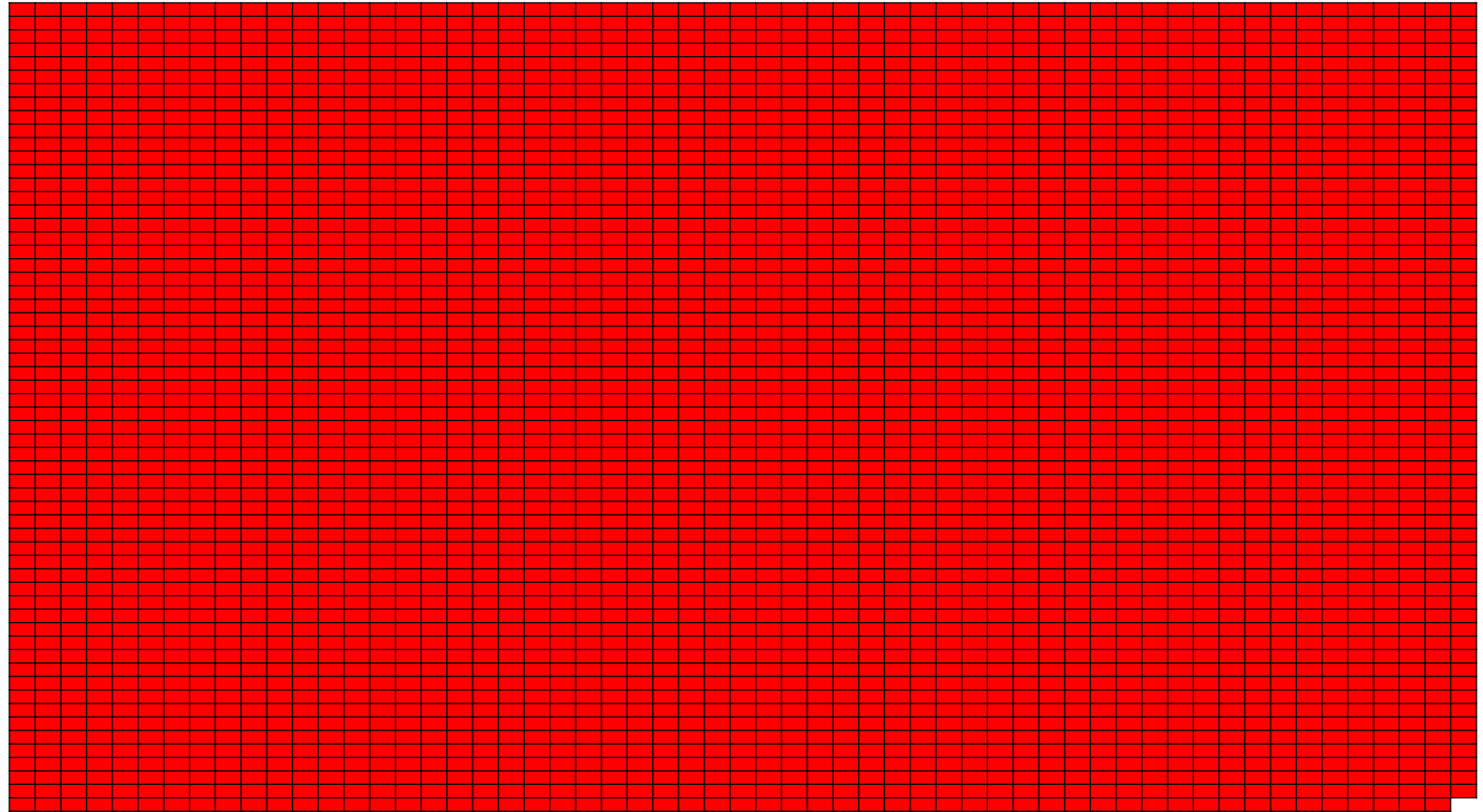
99.99% detection probability

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

Identifying IFDIS Test Candidates

Analyze Maintenance Data

Identify:
- NFF's
- Poor performers
- Un-repairable
- Chassis architecture
- Feasibility Study

Test Candidate?

No → **Other Remediation Option** → **Test, Repair and Return to Service**

Yes → **Perform Diagnostics** → **Repair Chassis or wiring harness** → **Retest with IFDIS**

LRU / WRA Removal

Collect Maintenance and Performance Data

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

Intermittent Fault Detection & Isolation System (IFDIS)

"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

Ogden Air Logistics Complex

USAF Intermittence Testing

Mr. Les Stone
Director
523rd EMXS

Air Force Problem

- **Conventional testers were unable to detect the problem in F-16 Modular Low Power Radio Frequency (MLPRF) LRUs 51% of the time**
- **Discovered chassis intermittent circuits in 1999**
  - **Using a microscope, found ribbon cable had cracked solder joints**
  - **MLPRF SRUs had 90% NFF rate**
  - **Initiated massive ribbon cable re-soldering program**
- **No depot tester could detect intermittent circuits**

Air Force Solution

- **Discovered IFDIS capability in 2006**
- **Stood up two systems in 2009 through SBIR Phase III vehicle**
  - **One in F-16 MLPRF repair shop**
  - **One in "Bad Actor" laboratory**
- **IFDIS Tested over 400 MLPRFs**
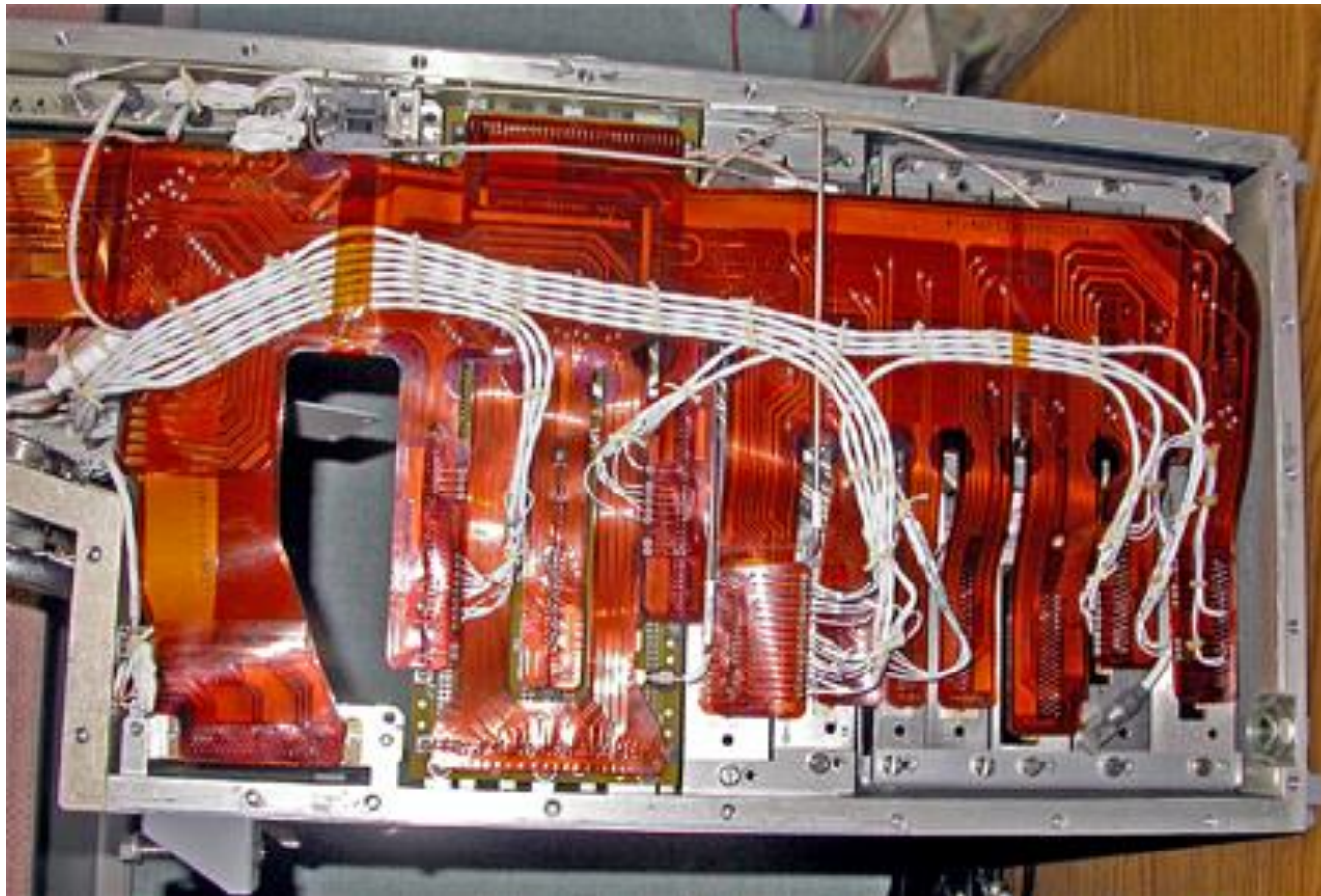- **Over 28 times ($62M) return on investment in less than three years**

MLPRF Chassis

MLPRF Results

- **Intermittent faults detected and isolated in over 60% of the units IFDIS tested (over 400 MLPRFs)**

- **Increased Mean Operating Hours Between Depot Repair from 290 to 926 hours (Tripled)**

- **Near the top of the MICAP list for over a decade, now not even on the MICAP list**

- **Troubleshooting time reduced by over 50%**

Current IFDIS Testing

- **IFDIS testing F-16 Radar Antenna, CADC and C-17 Power Supply**

- **Stood up 8000+ channel system in Jan 2015**
  - **Capable of testing F-16 Programmable Signal Processor (PSP) – Unreliable & costly to sustain**
  - **Plan to expand IFDIS testing to many LRUs**
  - **Will be capable of testing virtually any LRU in the USAF inventory, as well as Joint Service LRUs**

8000 channel IFDIS

F-16 PSP

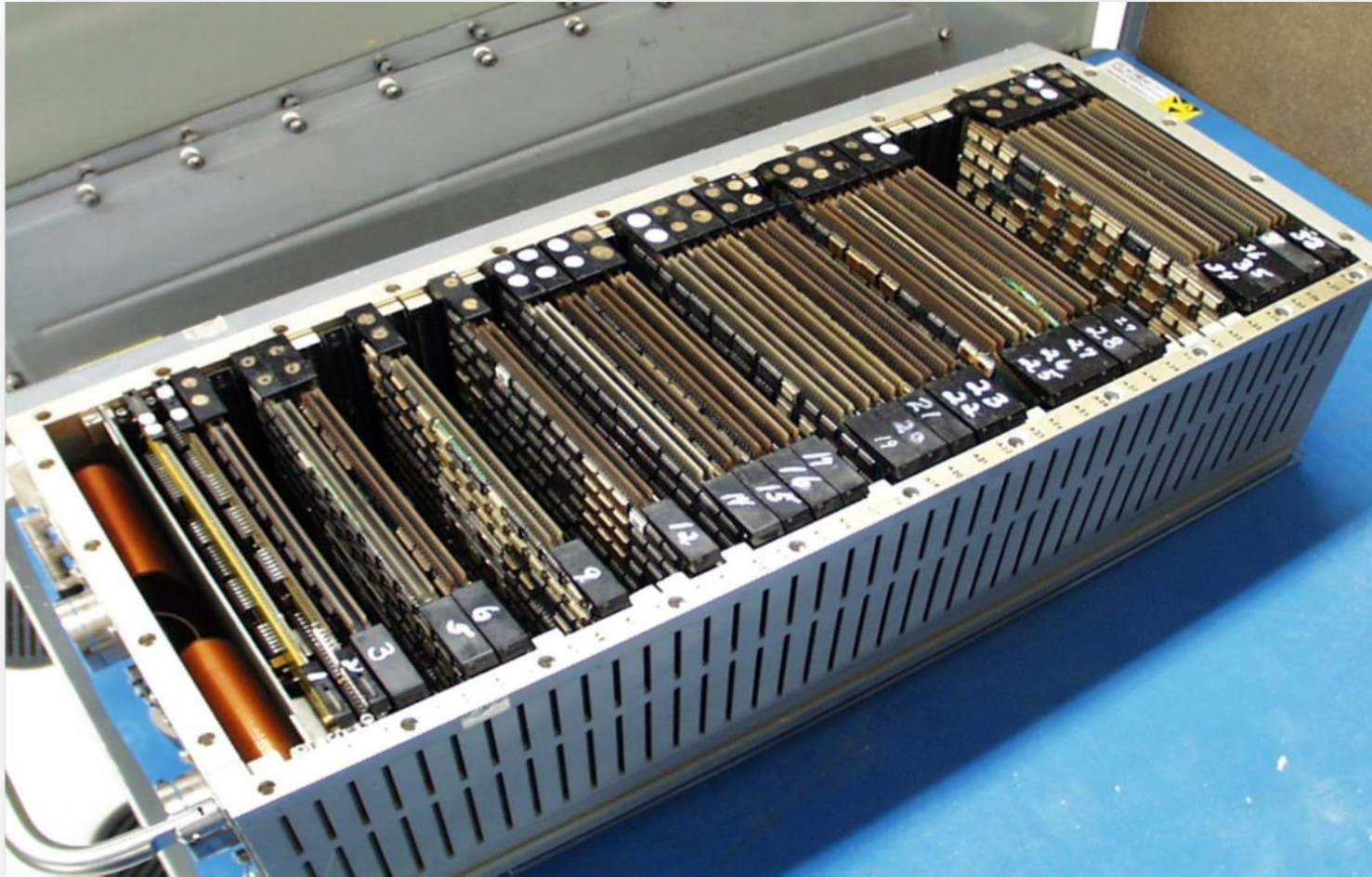# Air Force Summary

- **IFDIS was great investment – amazing ROI**
- **Solving our intermittent / NFF circuit problem**
- **Reliability improvement greater than expected**
- **Reducing Air Force maintenance costs**
- **Expanding to other LRUs as rapidly as possible**
- **Currently have large enough IFDIS to test any LRU in the USAF inventory, as well as Joint Service LRUs**

Questions?