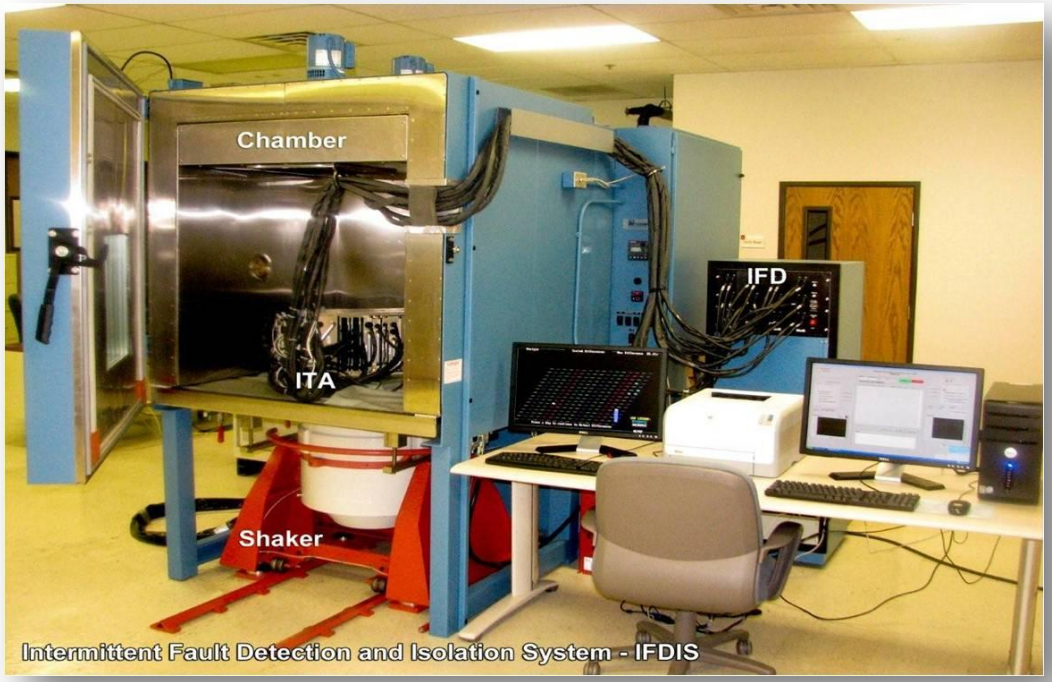
Intermittent Fault Detection & Isolation System (IFDIS)



Mr. Ken Anderson
Vice President
Universal Synaptics Corp.

Department of Defense Maintenance Symposium and Exhibition
November 13-16, 2012

Problem

- Approximately 50% of the malfunctioning LRUs/WRAs inducted into the depot for repair are not actually repaired
  - Test No Fault Found (NFF)
  - Disassembled, Cleaned & Reassembled (DCR)
  - Circuit cards are reseated
  - SRUs/SRAs are replaced which subsequently test NFF
- NFF activity costs DoD $2B to $10B annually

Problem

- Conventional test equipment is incapable of detecting intermittent circuits in LRU/WRA chassis
  - Cracked solder joints
  - Loose wire wraps
  - Loose crimp connections

- These electromechanical devices fail intermittently long before they fail permanently

Problem

- Consistent discontinuity (hard failure) can be detected using conventional equipment
- Intermittent discontinuity is very short in duration
- Often only seen during stress situations
  - High G loading – Thermal extremes
  - Vibration – Combination of stresses
- Conventional testers are not designed to detect intermittent faults
  - Test one circuit or function at a time (sequential testing)
  - Scans, samples or averages intermittent faults out
  - Lack of test coverage and sensitivity to detect random intermittent faults that cause NFF

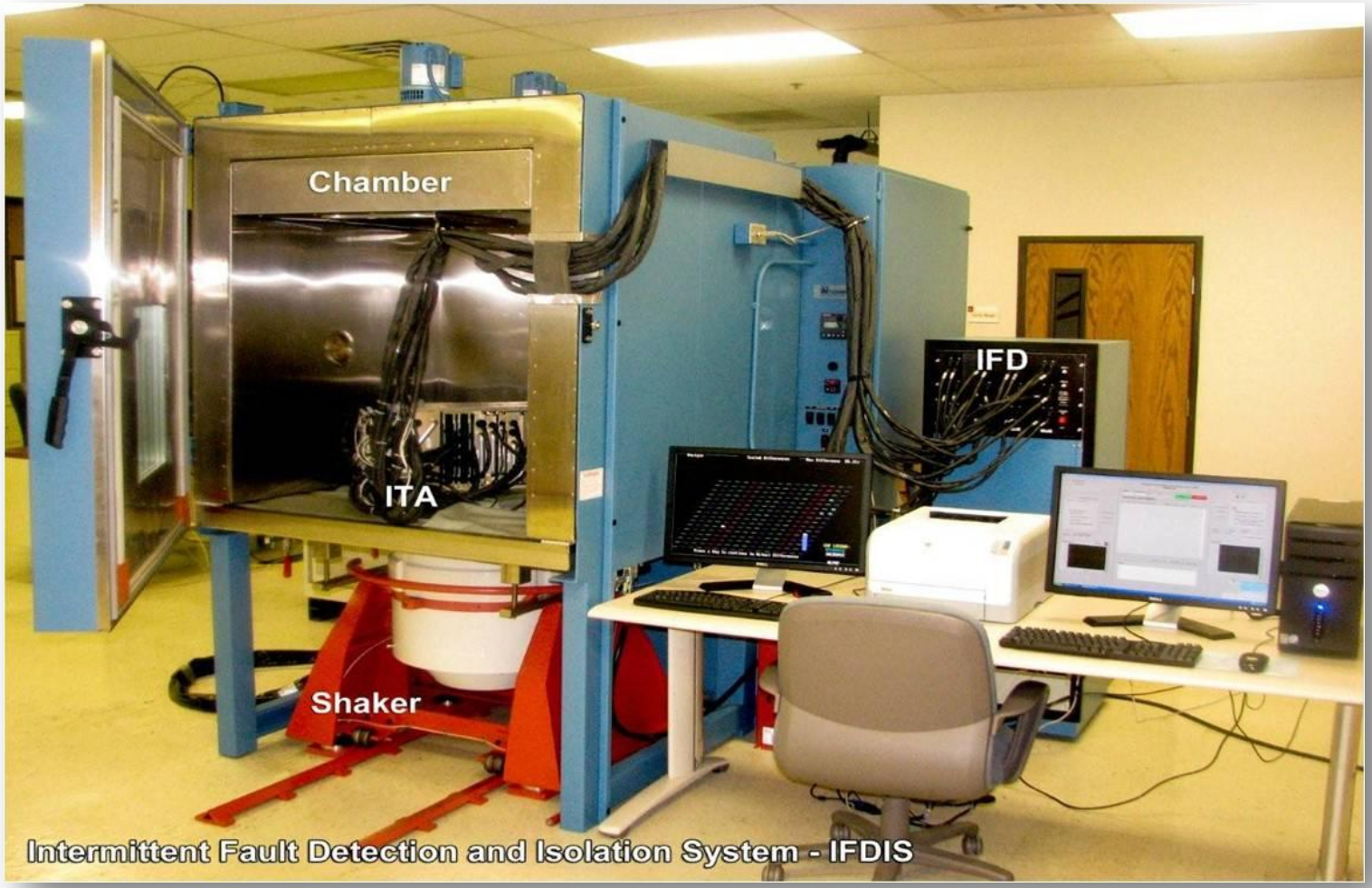
Solution

- Build a tester specifically designed to detect and isolate intermittent circuits
  - Must monitor ***ALL*** circuits (parallel testing) in a unit under test (UUT) ***ALL*** the time to prevent missing any random intermittent event
  - Must be sensitive enough to detect nanosecond range intermittent events
  - Must simulate operational environment
- The Intermittent Fault Detection & Isolation System (IFDIS) is such a tester

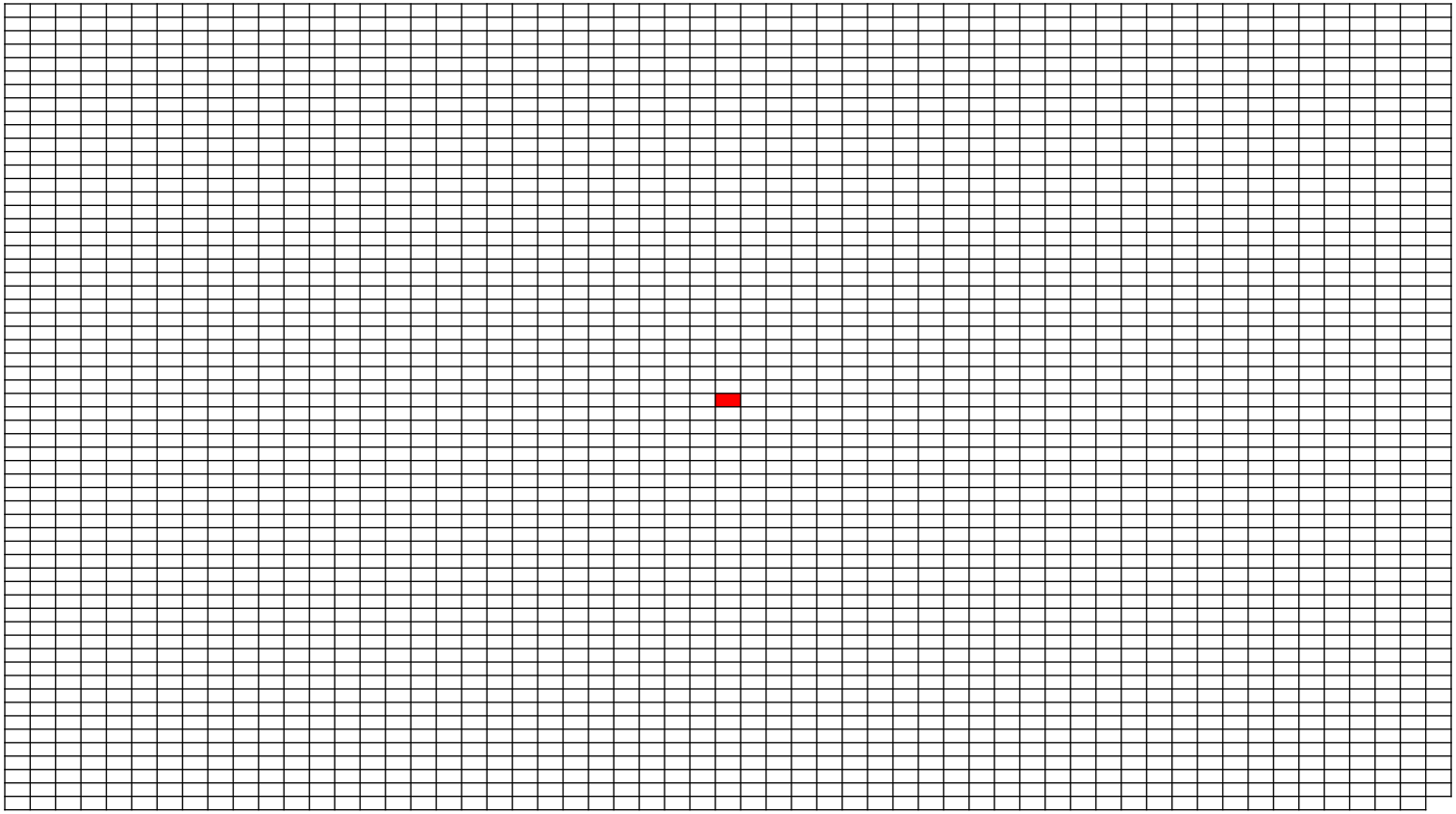
IFDIS Major Components

- Intermittent Fault Detector developed and patented by Universal Synaptics
  - Hardware neural network analog instrument
  - ***Individually, simultaneously*** and ***continuously*** monitors thousands of circuit paths
  - Detects and records **all** momentary discontinuities as short as ***20 nanoseconds***
- Shake table
- Environmental chamber
- Interface Test Adaptor (ITA)

IFDIS

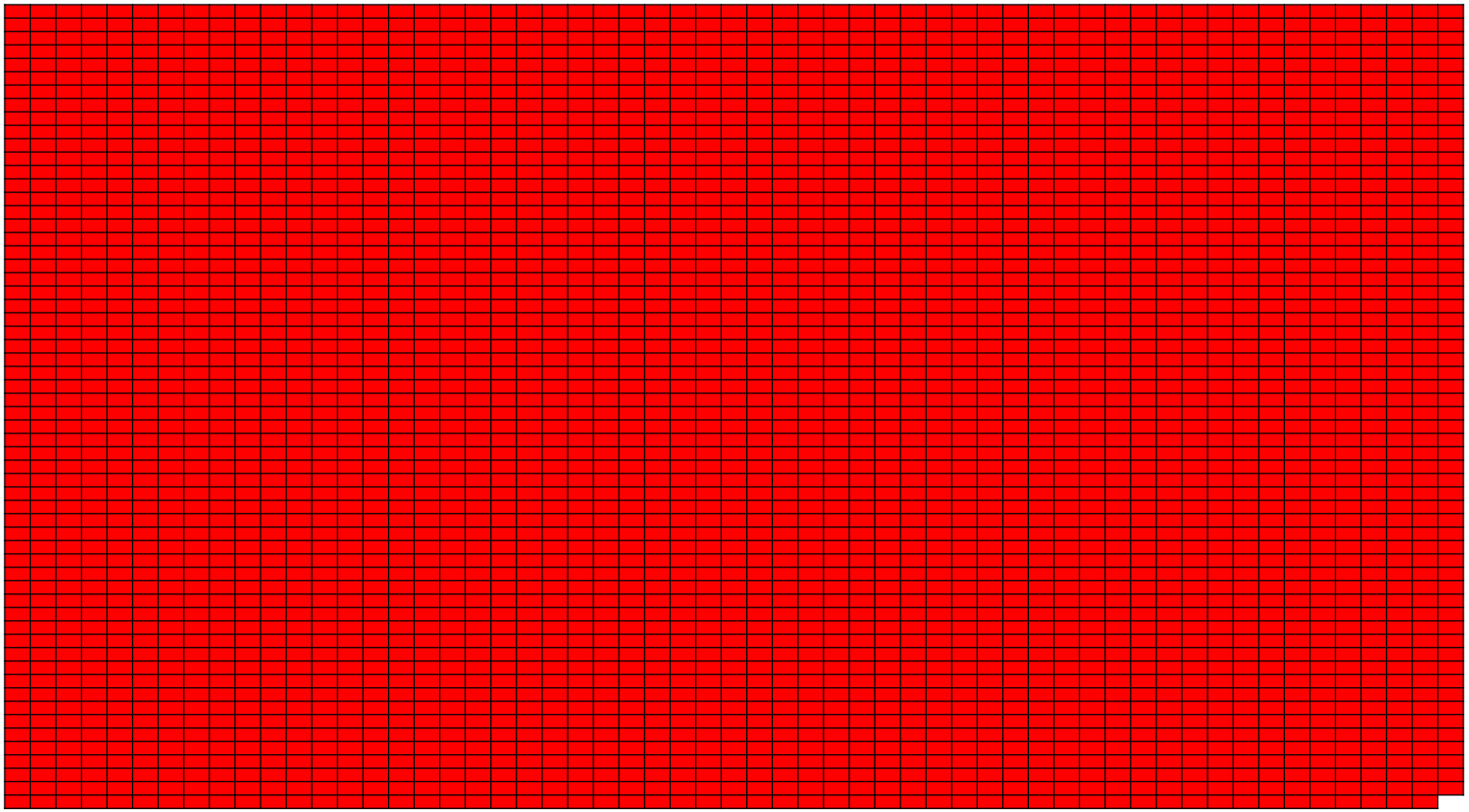

Chamber
IFD
ITA
Shaker
Intermittent Fault Detection and Isolation System - IFDIS

Conventional Tester Probability of Detecting a Random Intermittent Event



.03% detection probability

IFDIS Probability of Detecting a Random Intermittent Event



100% detection probability

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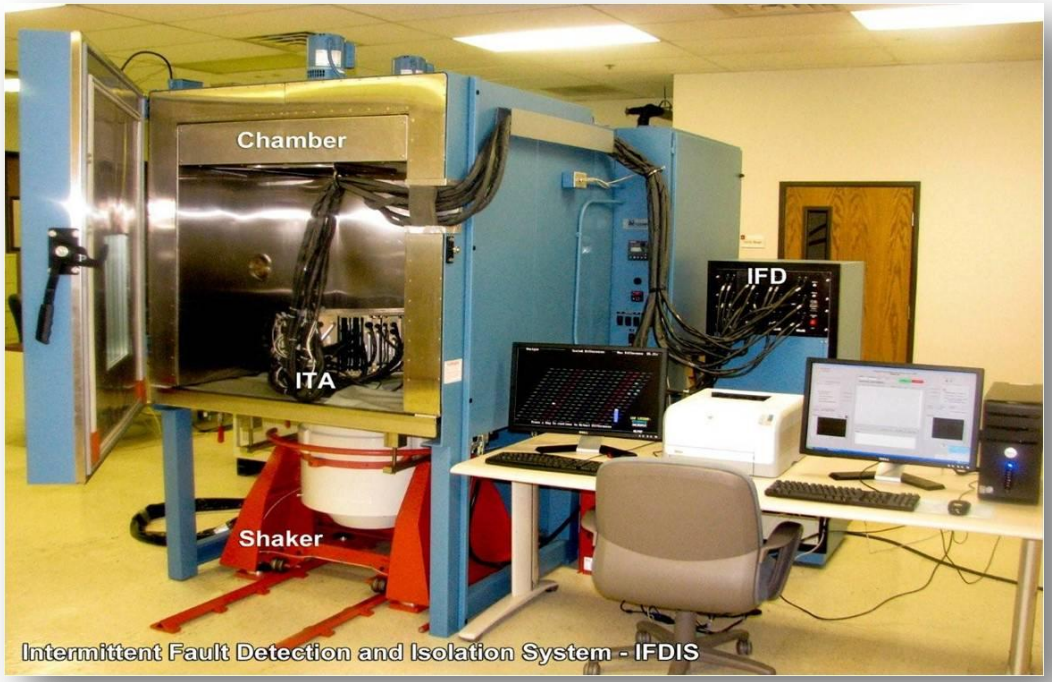

Mr. Sami Mansour
Director
523rd EMXS, USAF

Department of Defense Maintenance Symposium and Exhibition
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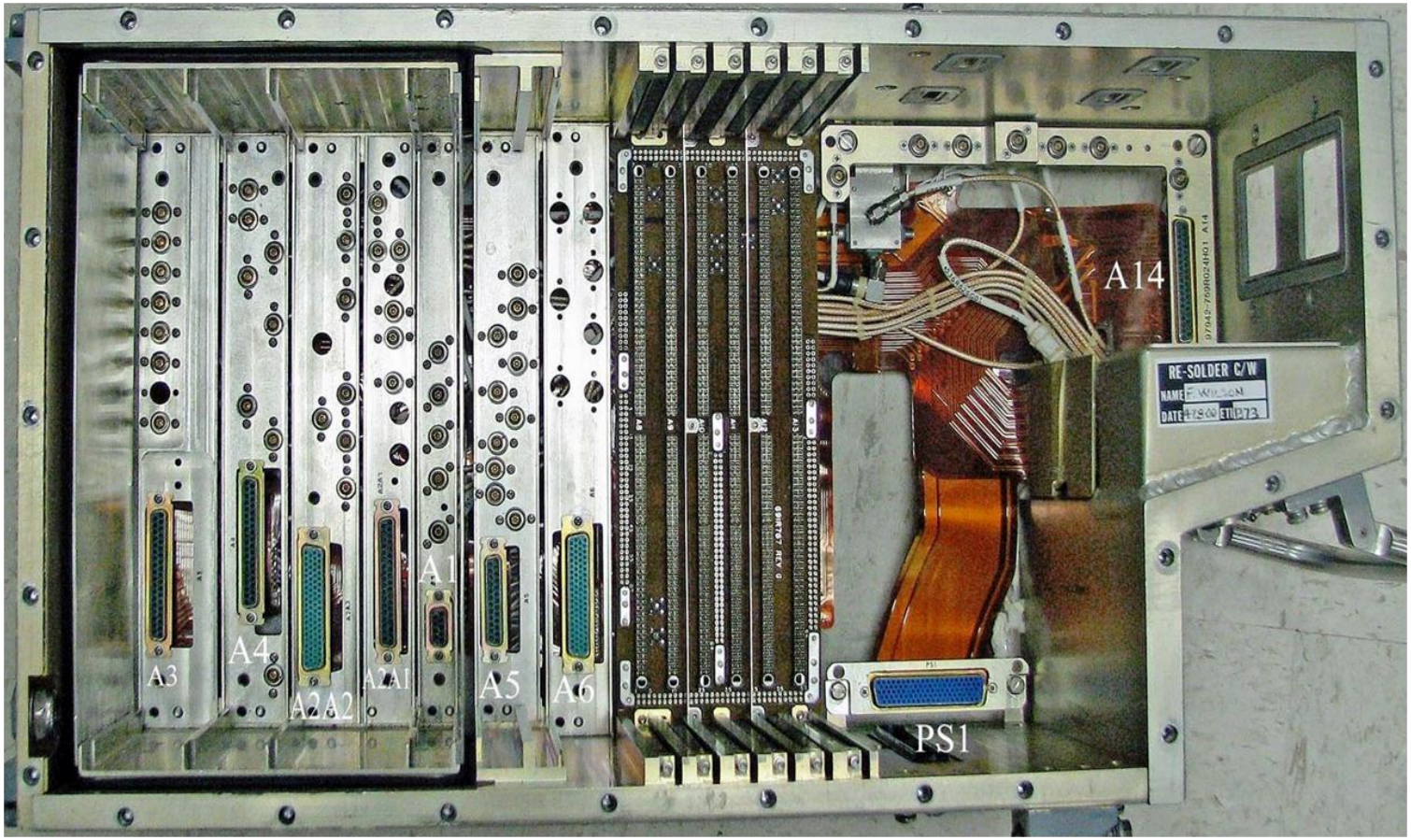
Air Force Problem

- Conventional testers are 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

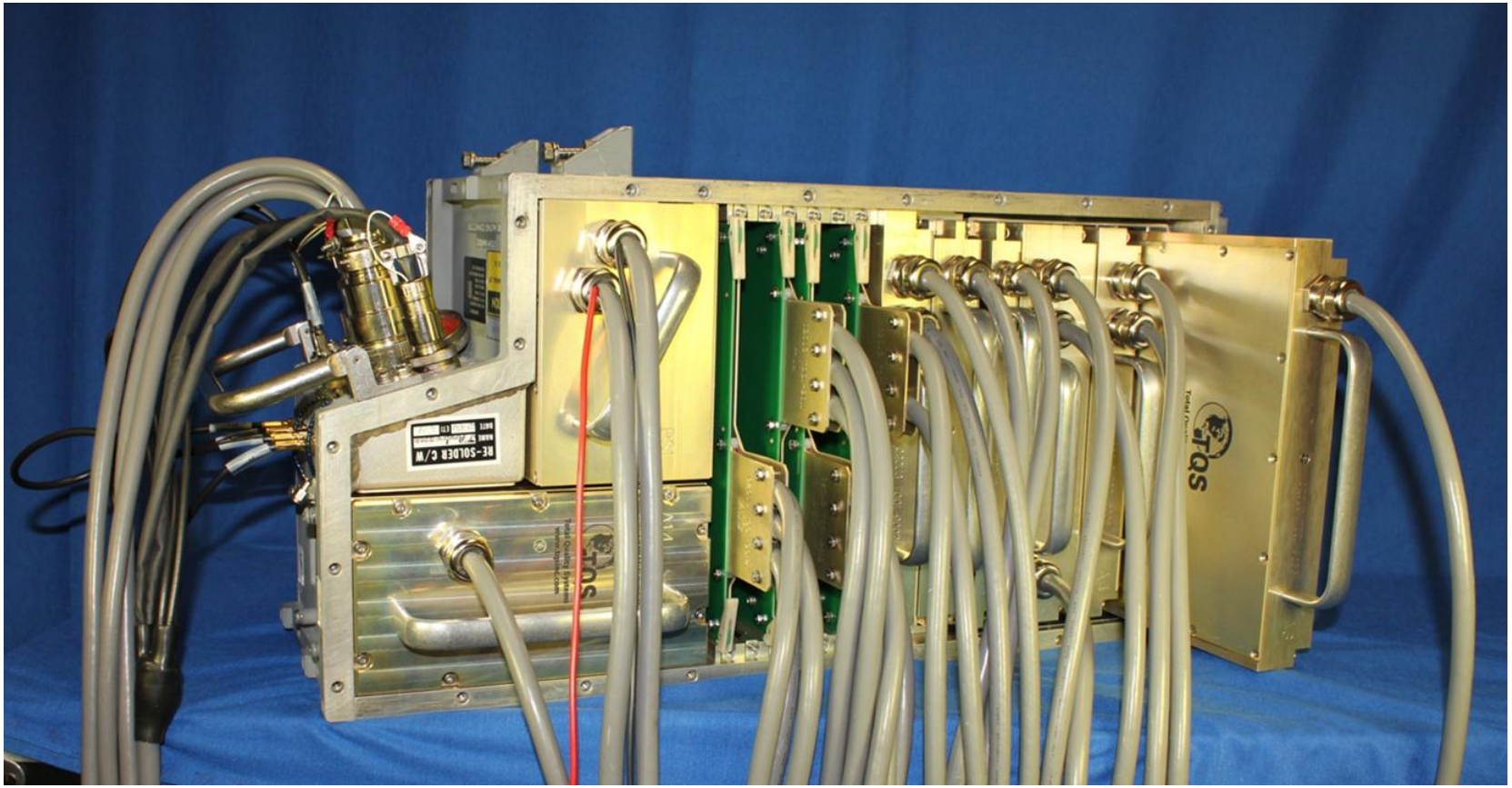
Air Force Solution

- 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 25 times ($56M) return on investment

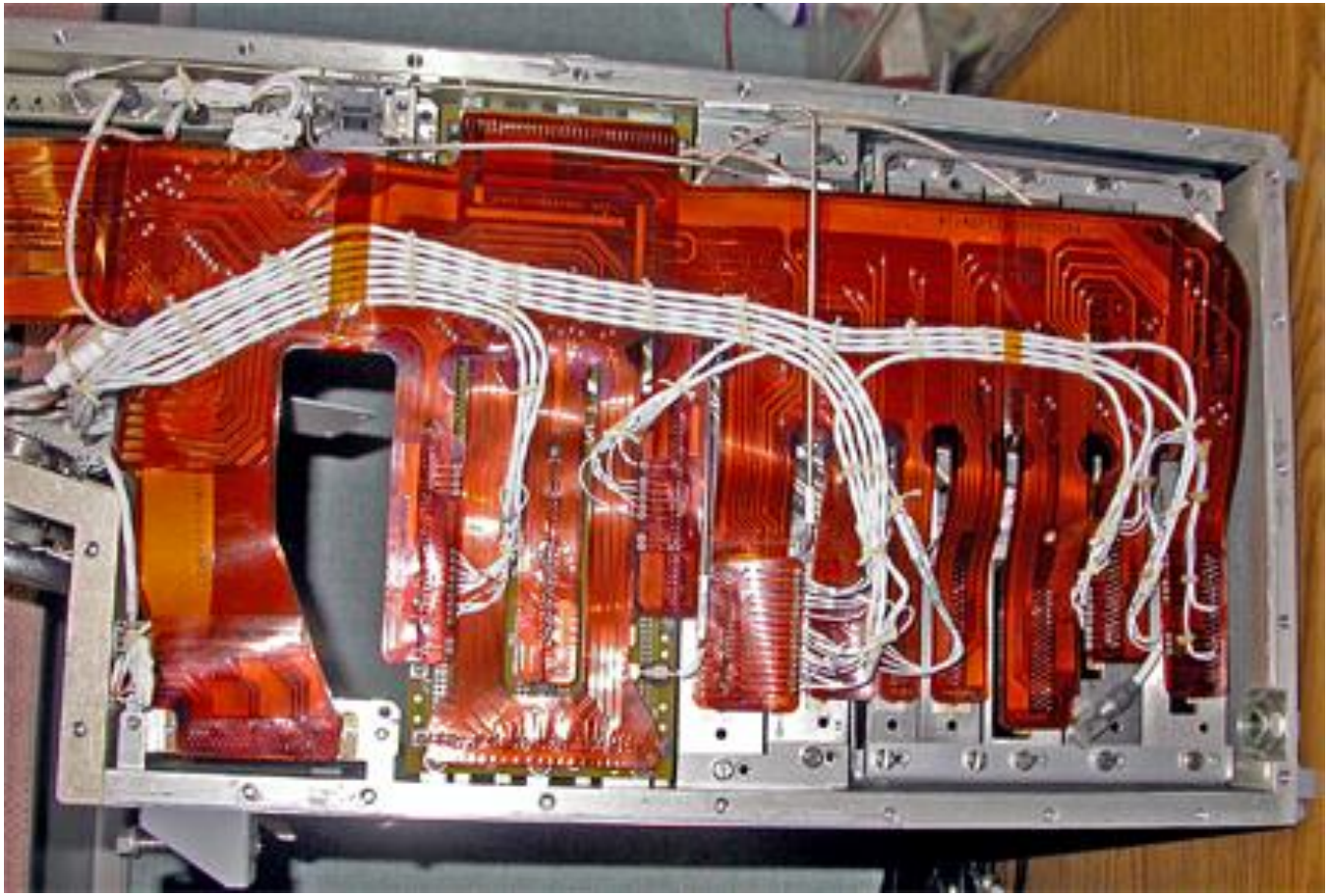
MLPRF Chassis



MLPRF With ITA Installed



MLPRF Ribbon Cable & Wiring



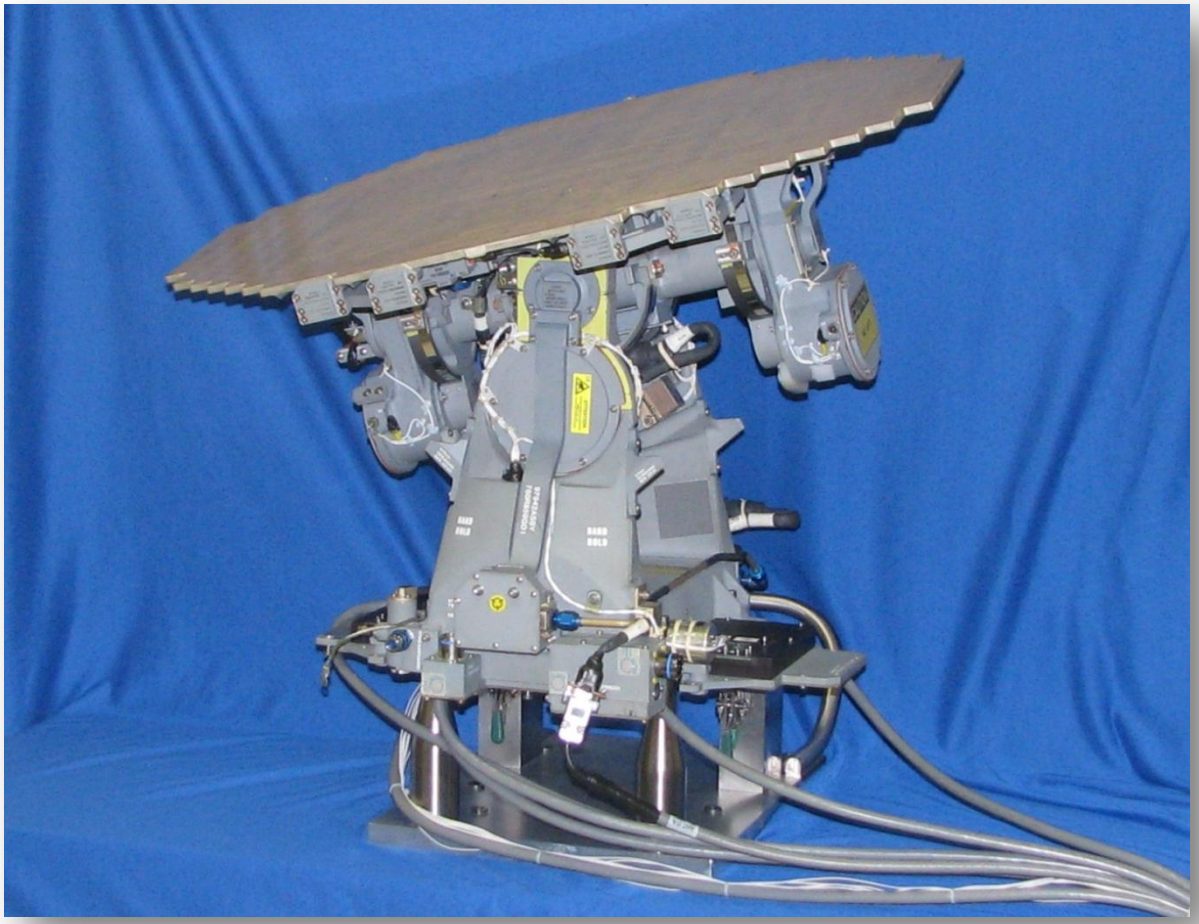
MLPRF Results

- Intermittent faults detected and isolated in over 58% of the units IFDIS tested (over 400 MLPRFs)
- Increased Mean Operating Hours Between Depot Repair from 290 to 926 hours (more than 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%
- Over 25 times ($56M) return on investment

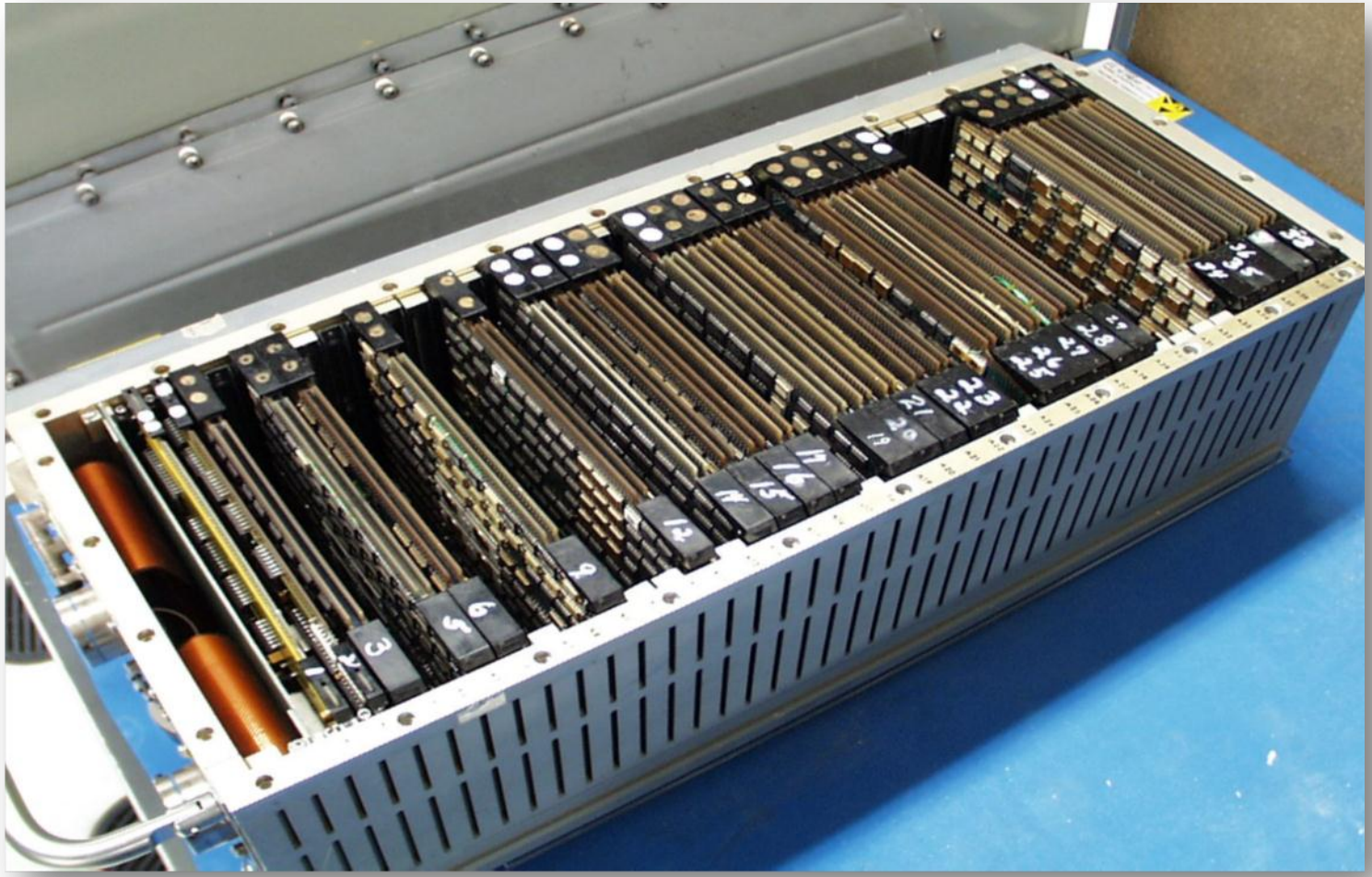
Future

- Recently started IFDIS testing F-16 Radar Antenna
- Plan to stand up 8000+ channel system in 2013
  - 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

F-16 Radar Antenna with ITA



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
- Next year should have large enough IFDIS to test any LRU in the USAF inventory, as well as Joint Service LRUs

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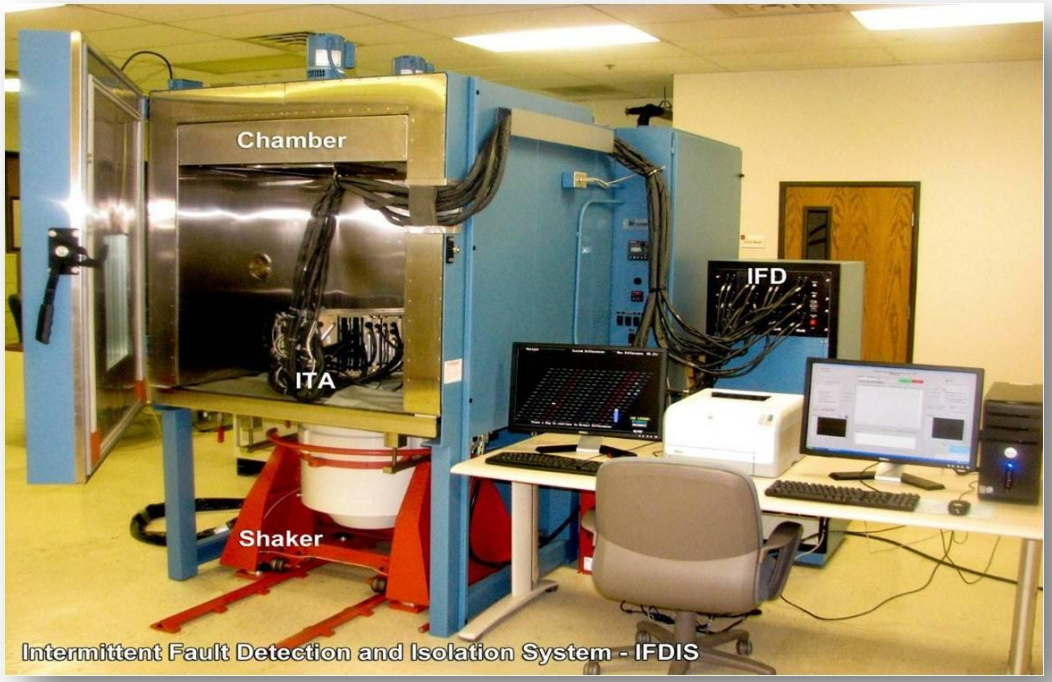

Mr. Brett Gardner
Avionics Advanced Aircraft Technologies (AAT)
Team Lead, FRC SW

Department of Defense Maintenance Symposium and Exhibition
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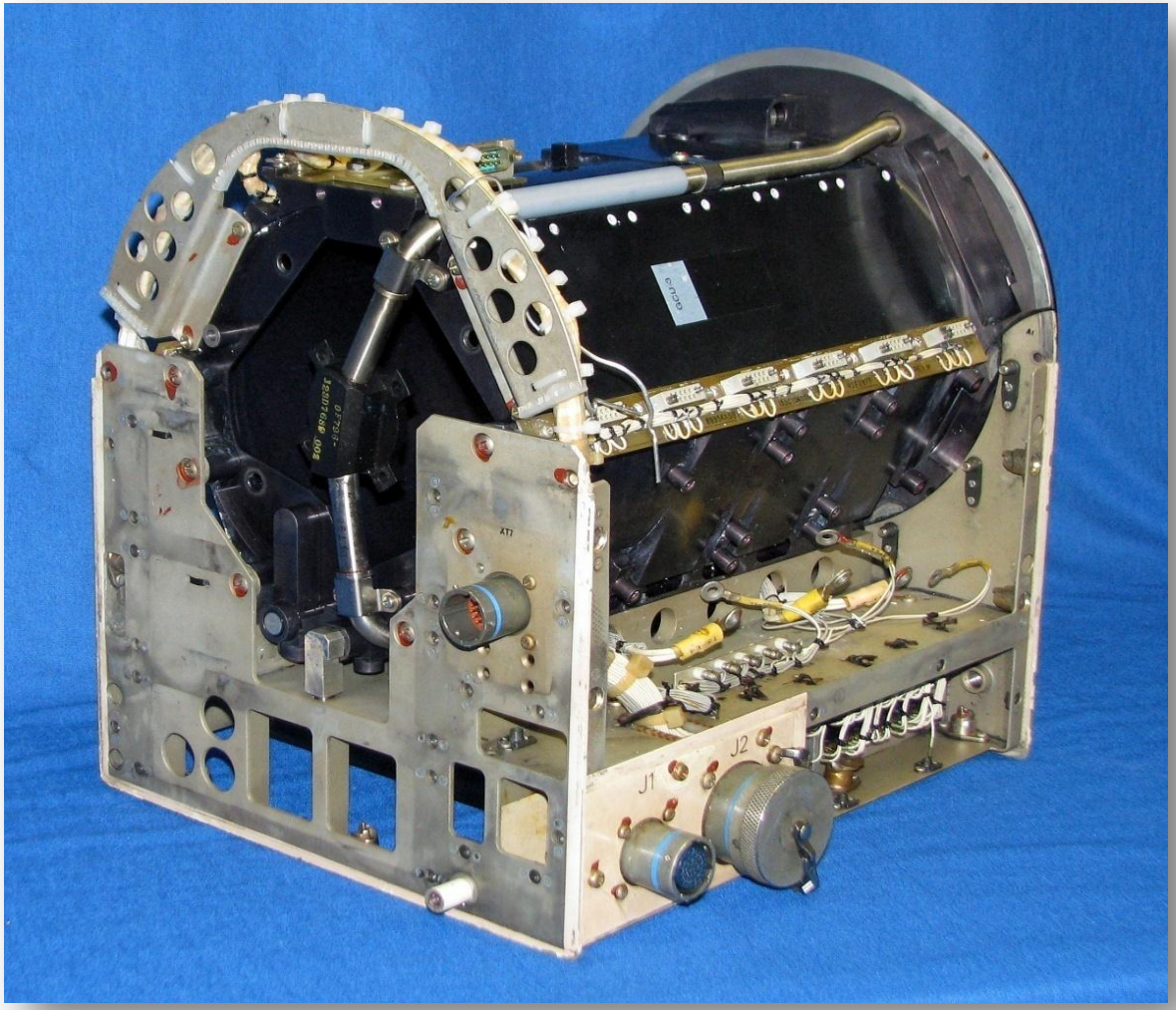
Navy Intermittent Fault Issues

- Intermittent / No fault found (NFF / A799) circuit problem with all Navy WRAs chassis
- F/A-18 Generator Convertor Unit (GCU) consistently appears on the F/A-18 top degrader list
  - GCU chassis currently tested with conventional continuity tester
  - Intermittent circuit detection extremely limited using conventional tester
- IFDIS technology was investigated by AAT 2010
- NAVSUP/F18 PMA funded GCU/IFDIS test demonstration

GCU Chassis



GCU Tied to IFDIS

GCU Intermittent Wire

IFDIS precisely detected and isolated one or more intermittent circuits in 80% of the GCUs tested

Navy Results

- Selected (5) Ready for use (RFU) F18-C GCU chassis for IFDIS testing
- IFDIS detected and isolated intermittent circuits in 80% of the RFU GCU Chassis
- IFDIS stand up 2014 at FRCSW as part of Capital Improvement Program (CIP)
- Several other FRCSW NAE top degrader chassis are in the pipeline for IFDIS testing at FRCSW Depot, APG-73/65, E2 MC, F18 E/F/G GCU

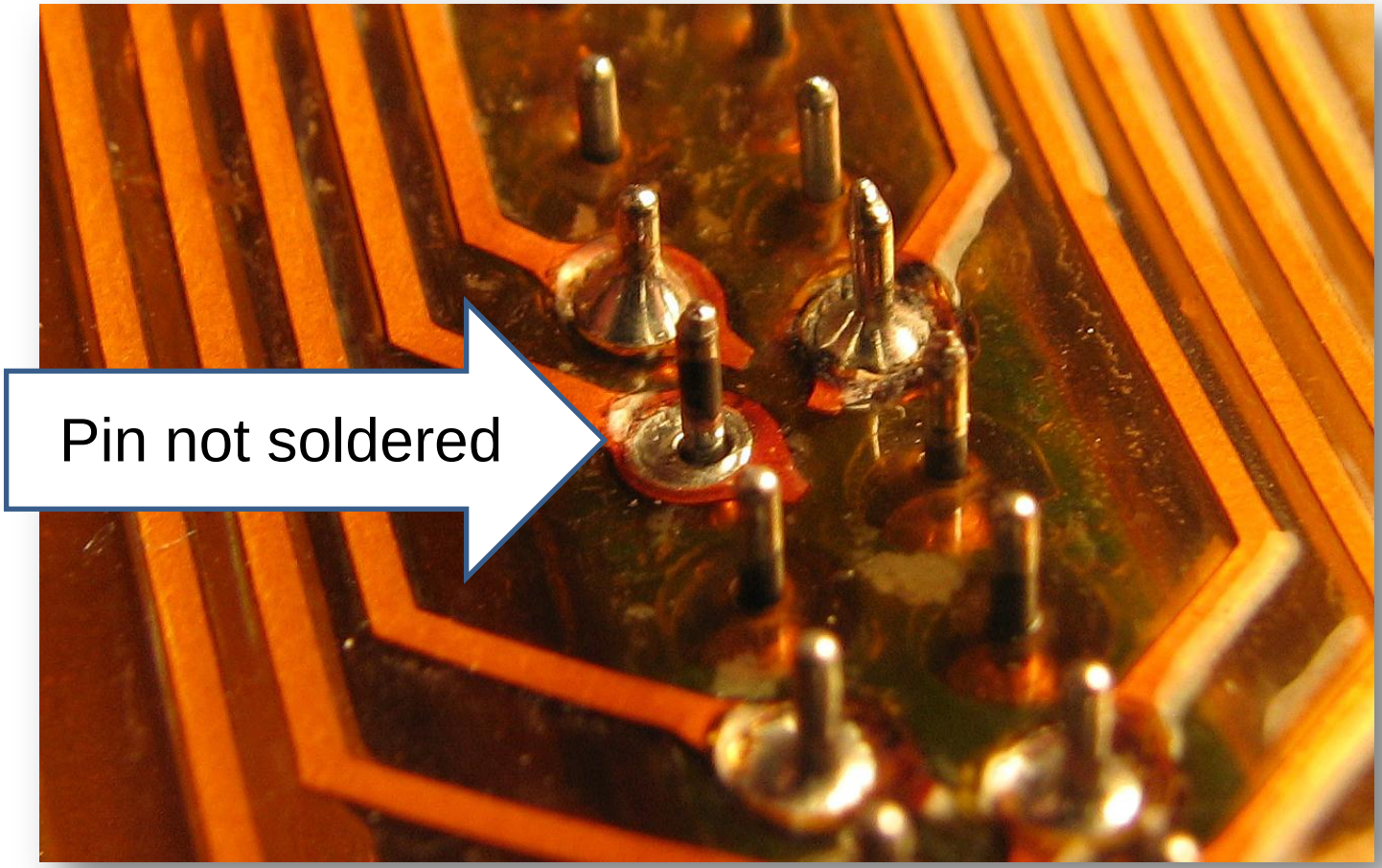
Navy Results Cont.

- IFDIS is self learning – requires limited engineering oversight and $$ to program
- Repeatable results – Operator can repeat testing as required to verify vibration and temperature related faults
- Verification – Once repaired, chassis is re-run on IFDIS to verify repair
- Cable assemblies and hold down fixtures manufactured locally at low $$ using standard parts readily available in supply
- Interface compatible with Automated Wire Test Set (AWTS)
  - Leverage off of I-level AWTS interface
  - Systems deployed with AWTS IDs compatible with IFDIS

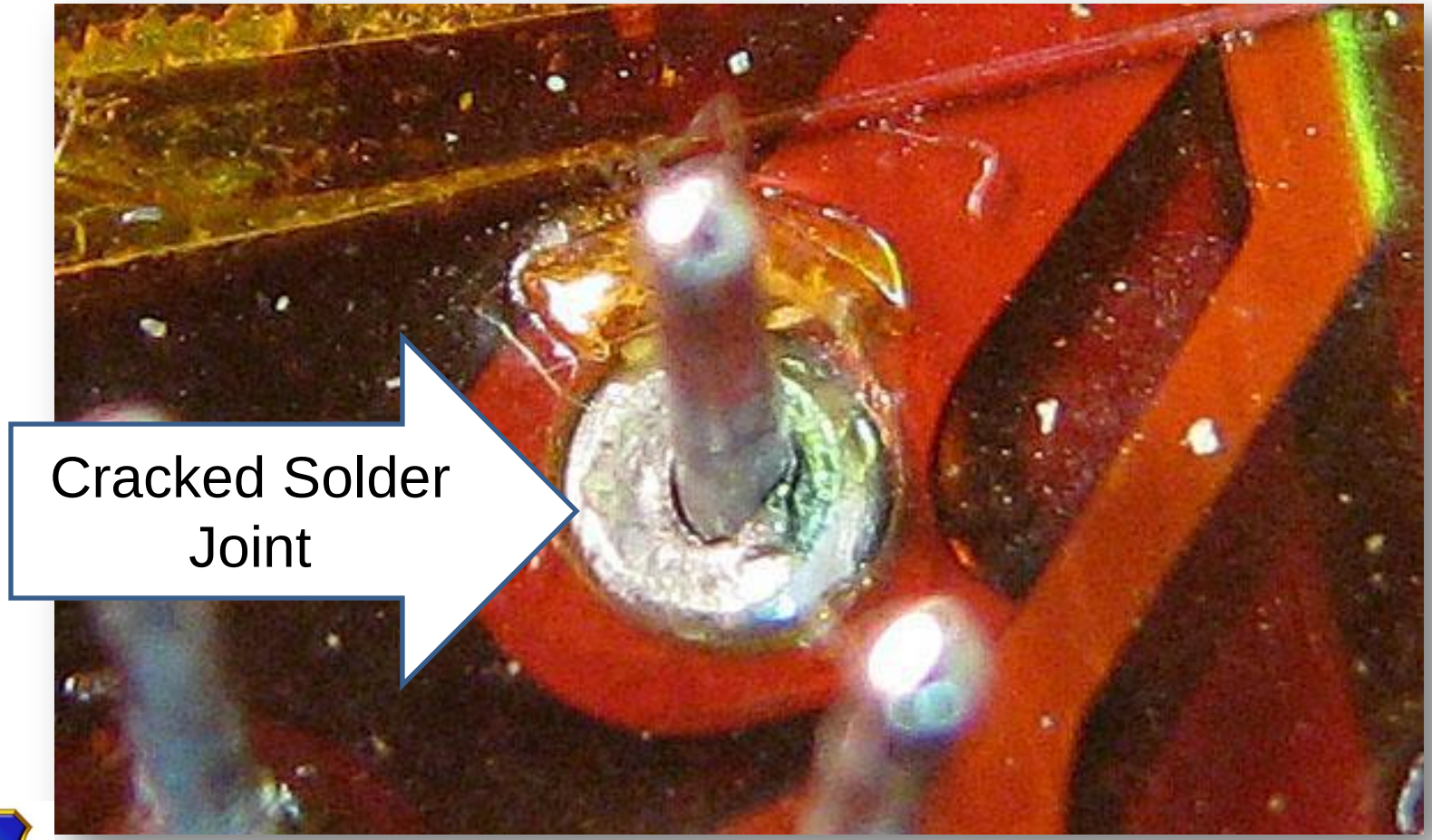
Questions?

Back up slides

Intermittent Fault Causes

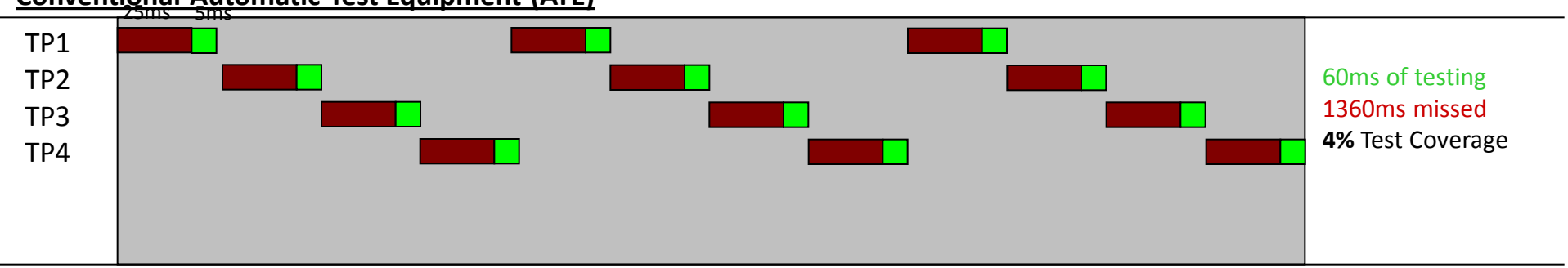


Intermittent Fault Causes



Test Coverage 101

Conventional Automatic Test Equipment (ATE)



*Note – Conventional ATE scanning measurement window must perfectly synchronize with fault at the precise moment the fault occurs or the fault is missed completely, the result is No Fault Found.

IFDIS

*Note – All lines All the time test coverage equals no missed defects!