

No Fault Found or more correctly,  
Fault Not Found;  
its causes, its costs and its correction

aka: How the USDOD is  
**Reducing No Fault Found**  
at Line & Base Maintenance

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# Scope

NFF Chain of Events

Culture & Cost blockers

6 uncomfortable truths about NFF

Solution themes

Data Analysis, Training, Intermittent Fault Detection

USDOD Strategy for NFF Reduction

Intermittent Fault Detection case studies

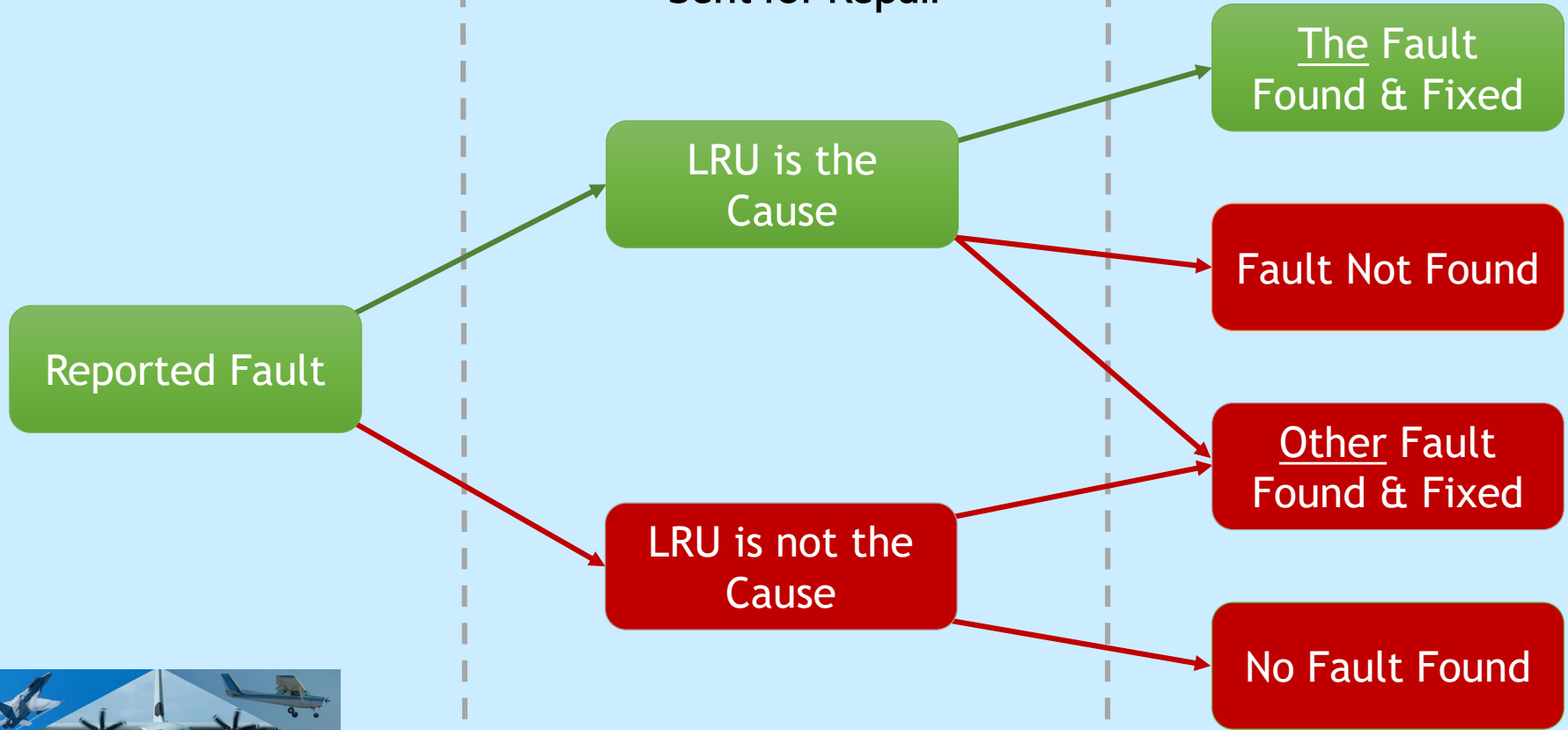
Conclusions



On-Aircraft Fault

LRU to be Replaced &  
Sent for Repair

LRU 'Repair'



On-Aircraft Fault

LRU to be Replaced &  
Sent for Repair

LRU 'Repair'



LRUs THAT FREQUENTLY CIRCULATE  
ROUND THIS CHAIN OF EVENTS ARE  
**ROGUE LRUs** - ALSO KNOWN AS  
'REPEAT OFFENDERS' OR 'BAD ACTORS'



On-Aircraft Fault

LRU to be Replaced &  
Sent for Repair

LRU 'Repair'

REPEAT OFFENDER SYSTEMS ON  
INDIVIDUAL AIRCRAFT THAT FREQUENTLY  
RESULT IN ERRONEOUS LRU REJECTIONS  
ARE **ROGUE SYSTEMS**

Reported Fault

LRU is not the  
Cause

Other Fault  
Found & Fixed

No Fault Found



# Culture & Cost blockers

## 6 UNCOMFORTABLE TRUTHS ABOUT NFF



# The most used name is a cover-up; NFF is the first uncomfortable truth:

THE PROBLEM IS STILL THERE!

A MORE APPROPRIATE NAME SHOULD BE

FAULT NOT FOUND



# NFF has an image problem

NFF ISN'T SEXY, BUT IT'S **UNSEXY** \$MULTI-MILLION PROCESS  
**WASTE** ON A LARGE SCALE





# "NFF isn't a safety issue"

EXCEPT WHEN YOU KEEP REPLACING THE SAME LRU AGAIN AND AGAIN UNTIL THE AIRCRAFT CRASHES (AIR MALAYSIA QZ8501)





## Flight 8501



Indonesia's National Transportation Safety Committee traced the sequence of events that led to the crash starting with a malfunction in the plane's Rudder Travel Limiter Units (RTLUs).

**A soldered electrical connection in the plane's RTLUs was found to be cracked, likely for over a year, causing it to intermittently send amber master caution warnings to the Electronic Centralised Aircraft Monitor.**

The plane's maintenance records showed that the RTLUs warning had been sent **23 times** over the previous year, but was always solved by **resetting** the RTLUs system (and never further investigated, which could have addressed the underlying electrical problem).



# "We can't introduce [*NFF solutions*] because of our existing policies & procedures"

IF YOUR CURRENT POLICIES GET IN THE WAY OF YOU FIXING AIRCRAFT RIGHT FIRST TIME THEN THOSE POLICIES NEED TO BE CHANGED



# Not solving NFF is normalised because the costs are hidden

EVEN THOUGH IT ISN'T HARD TO DO THE SPECIFIC COST & IMPACT  
OF NFF, THESE ARE RARELY ANALYSED OR ADDRESSED BY KPIs



# The data shows a very low NFF, less than 1%. We are fine!

PLATFORM NFF IS A MILITARY DERIVATIVE OF A COMMERCIAL AIRCRAFT [NFF <.001%]....ADDED FUNCTIONS NFF >30%.



There's no time to investigate root causes, but there is time to repeat the repair again... *and again... and again...*

REPAIR BY LRU REPLACEMENT IS NORMALISED, BUT EVEN THE MOST BASIC DATA ANALYSIS WILL SHOW WHERE REPEATED LRU REPLACEMENTS FIX FAULTS CORRECTLY AND WHERE THEY DO NOT



# Solution themes

Data Analysis

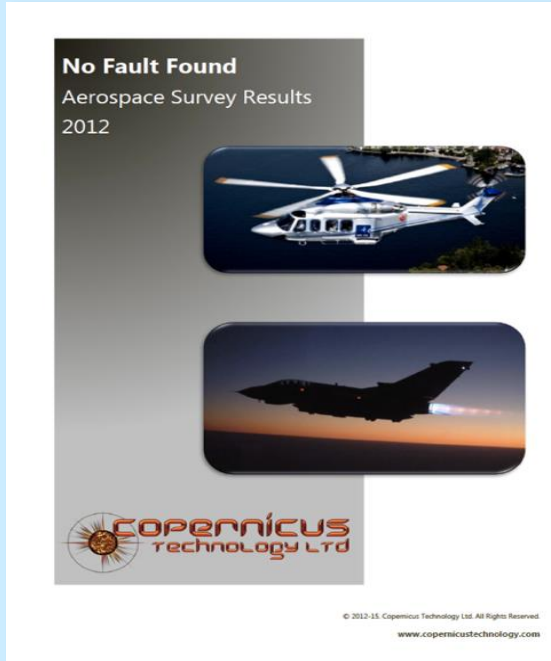
Training

Intermittent Fault Detection

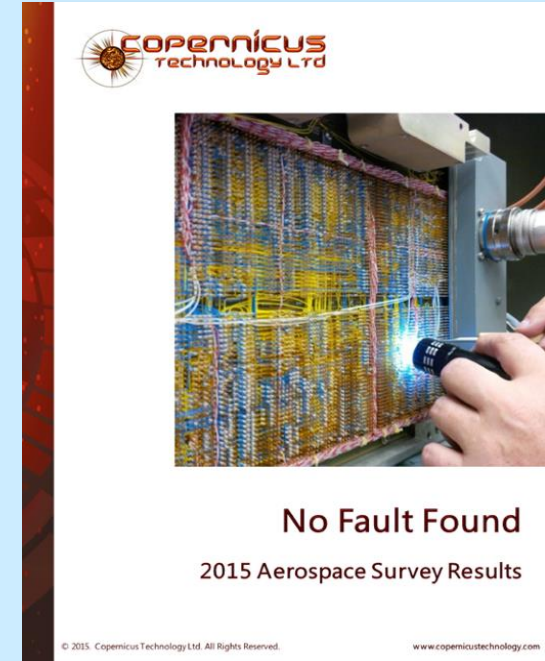


# NFF Aerospace Industry Surveys

2012



2015





# NFF Aerospace Industry Surveys

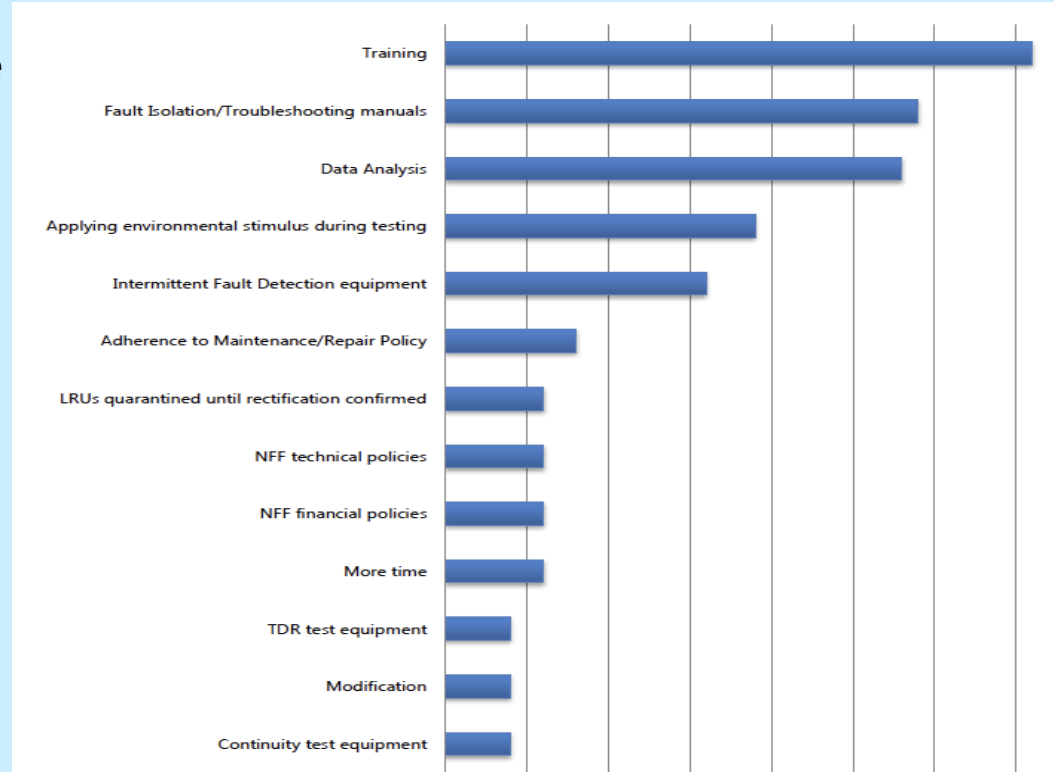
## 2012 Best NFF tools?

- 1 - Technician Training
- 2 - Aircrew Training vs Symptom Capture
- 3 - Improved Fault Isolation Manuals (FIMs)

## 2012 Top NFF tools used

- 1 - Data Analysis
- 2 - Technician Training
- 3 - OEM on-call support

## 2015 Best NFF Tools?



# NFF Aerospace Industry Surveys: Conclusions

The value of **knowledge-based** solutions to NFF reduction is well understood:

- Maintenance Data Analysis
- Training
- Fault Isolation/Troubleshooting Manuals

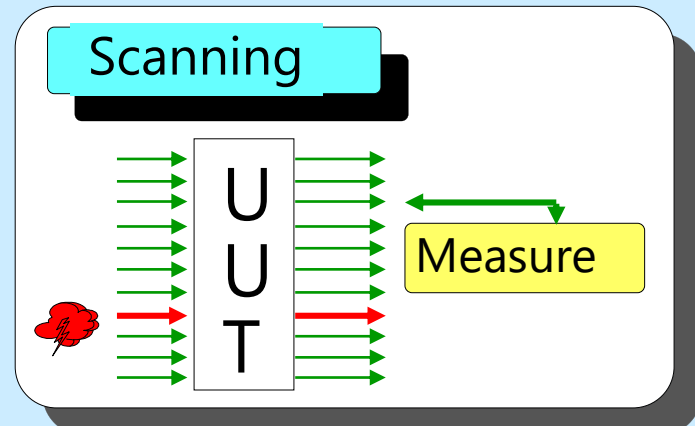
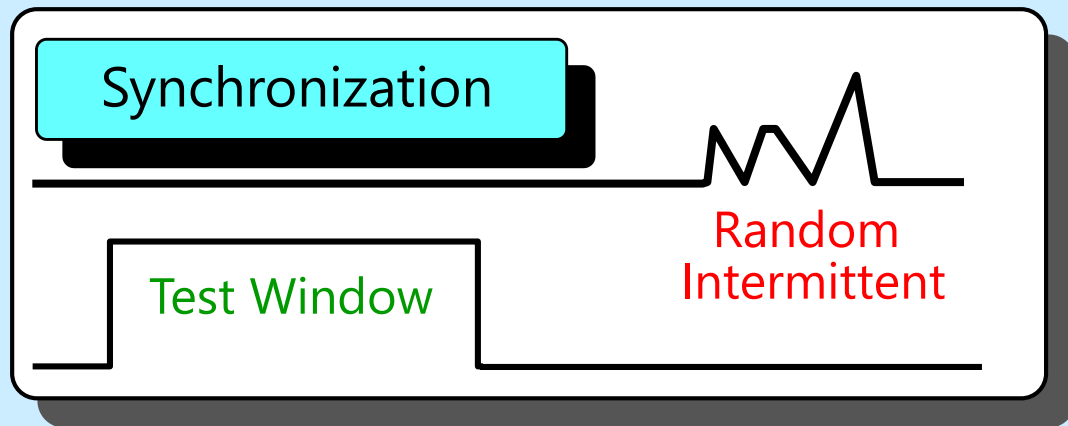
**Data Analysis** is essential to identifying, quantifying & prioritising NFF causal factors

Targeted improvements to **Training** & Fault Isolation Manuals accelerate the diagnostic process from symptom reporting to root cause identification

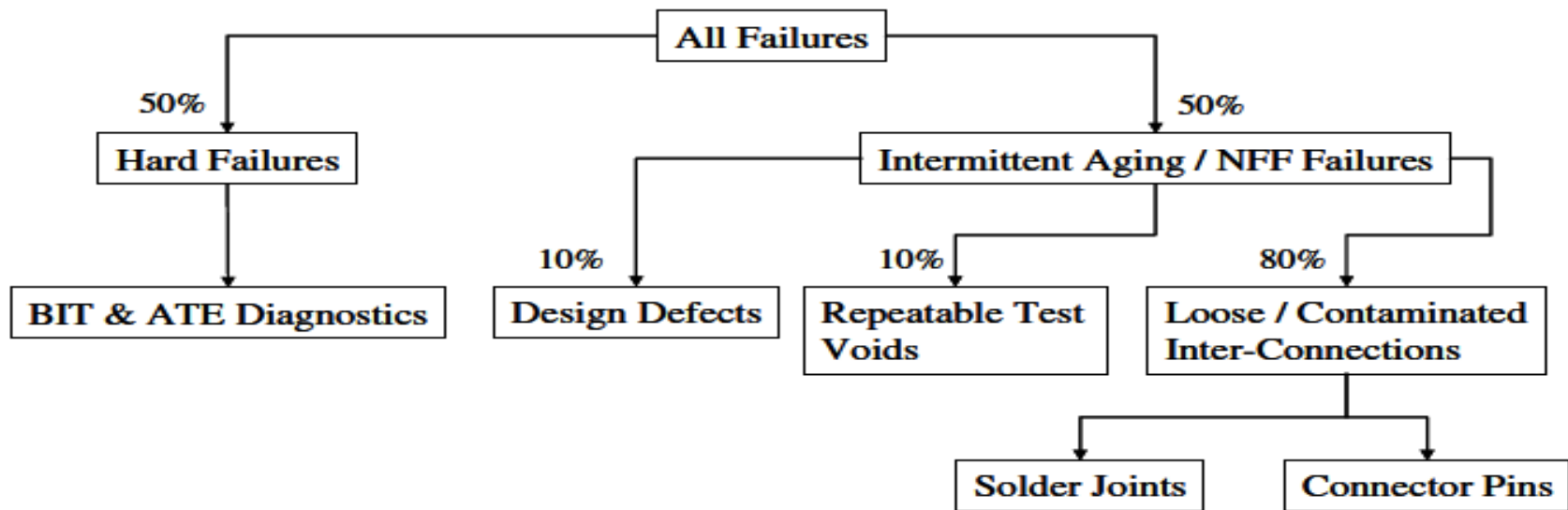
The final obstacle is dealing with **Intermittent Faults** *because Fault Isolation Manuals, training, fault recording and ATE are 'hard' fault-centric*



# Intermittent Fault Detection: Detection vs Measurement



# Intermittent Fault Detection: Detection vs Measurement



Source: Sorensen, B., *Digital averaging - the smoking gun behind 'No-Fault-Found'*, Air Safety Week, 24 Feb 2003.

# Intermittent Fault Detection: Conclusions

Data Analysis identifies...

- High hit 'Repeat Arisings' and NFF
- Rogue Systems
- Rogue LRUs

..and, therefore, where to target use of Intermittent Fault Detection (IFD) testing



# USDOD Strategy for NFF Reduction



# Condition Based Maintenance+ Joint Intermittence Testing Working Integrated Project Team (JITWIPT)

“Cost impact across USDOD of related No Fault Found is \$2 billion annually”

“Documented military weapon system verification and validation results indicate that three out of four aircraft in a mission ready status contain electrical interconnect issues”

## JIT WIPT Charter goals:

- Define and validate joint performance requirements for a **Joint Service intermittent fault detection system**
- Leverage current and emerging commercial industry activity for demonstration, testing, and cost analysis
- Publish a Military-Performance (MIL-PRF) requirements document



# Summary of JITWIPT Activity

Headed by Greg Kilchenstein, OSD

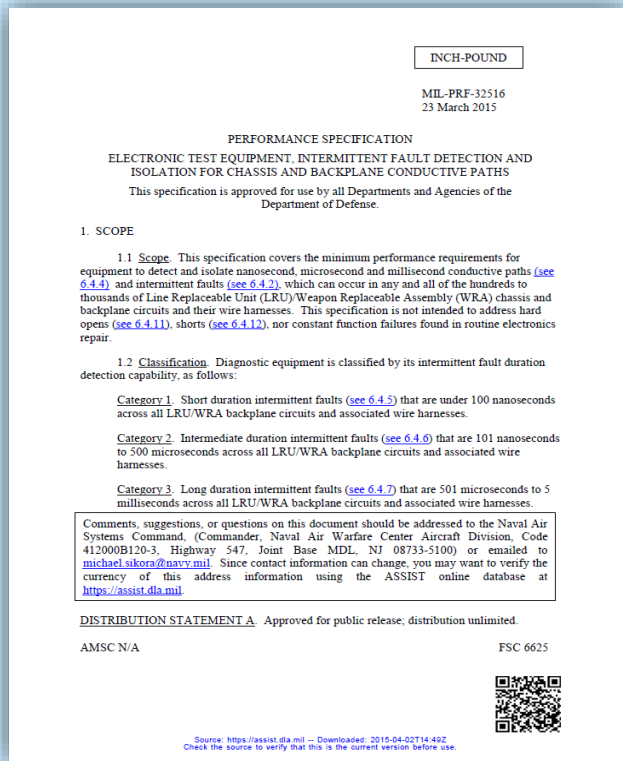
- National Centre for Manufacturing Sciences
- USAF
- USN
- USMC
- US Army
- USCG

2011	\$2B/year cost calculated
2012	JITWIPT formed
2015	MIL-PRF-32516 published (IFD performance spec)
2016	NAVAIR conducts IFE evaluations of candidate testers
2017	MIL-HDBK-527 published (Guidance for IFE)





# MIL-PRF-32516: Intermittent Fault Detection Categories



## Category 1

Short duration fault which is **under 100 nanoseconds** across all LRU/Weapon Replaceable Assembly (WRA) backplane circuits and their wire harness

## Category 2

Intermediate duration fault which is **101 nanoseconds to 500 microseconds** across all LRU/WRA backplane circuits and their wire harness

## Category 3

Long duration fault which is **501 microseconds to 5 milliseconds** across all LRU/WRA backplane circuits and their wire harness



# MIL-PRF-32516: Intermittent Fault Emulator (IFE) Evaluation



- Test Equipment manufacturers invited to supply products to undergo evaluation vs IFE at Naval Air Station Lakehurst in Jan 2016
- Universal Synaptics Corp provided Ncompass-Voyager portable IFD tester
- Ncompass-Voyager scored 100% in all 3 IFD categories of MIL-PRF-32516





# Intermittent Fault Detection Case Studies





## Ncompass-Voyager

Portable IFD for testing EWIS  
& interconnects  
(128 – 512 Test Points)



## IFD & Isolation System (IFDIS)

IFD for LRU chassis testing  
(1024 – 16,000+ Test Points)

# Intermittent Fault Detection Case Studies





# Proven on...



# Testing Rogue LRUs: F-16 & F-18



## F-16 MLPRF LRU

IFD testing of LRU chassis from half the fleet so far  
Bay repair throughput halved  
>300% Time-On-Wing increase to over 900 flying hours MTBUR

## F-16 PSP LRU

Was 54% NFF at Depot repair  
First 6 months testing recovered \$8M of LRUs  
Many intermittents caused by contaminated contacts (pictured)

## F-18 GCU LRU

A Top Ten 'Fleet Degradar' with very low MTBR  
>80% with intermittent chassis faults  
>400% Time-On-Wing increase



**Total savings >\$220M to date**



# Fast Jet Undercarriage Wiring

## Test Under Vibration





# Testing Rogue System Wiring: Chinook Automatic Flight Control System

High resistances & intermittent circuit breakers found

75% test time reduction vs conventional methods

Fault arisings reduced 10% - 89%





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# Testing Rogue System Wiring: Sikorsky S-92 Rad Alt System

Intermittent height indication fault for months

Numerous LRUs changed; antennas passed IFD testing

Intermittent cable fault found & replaced



# Conclusions: NFF

Rogue LRUs & Rogue Systems frequently implicated in NFF occurrences

Ingrained culture blocks improvement: the 6 Uncomfortable Truths of NFF

Essential components of NFF improvement:

- Cost impact data
- Maintenance Data Analysis
- Training
- Intermittent Fault Detection



# Conclusions: NFF and the USDOD



USDOD annual NFF cost impact of \$2B triggered implementation of the JITWIPT's activity

MIL-PRF-32516 performance spec for IFD introduced; 3 categories of intermittent fault duration

IFE used to evaluate IFD performance vs categories

Universal Synaptics' IFD test technology passed USDOD's IFE test against all 3 categories

NFF reduction achieved by Time-On-Wing and Fault Arising Rate improvements on fleets in US, UK, Europe

Further IFD procurements commenced by USDOD







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# Questions?

