Managing the “False Alarms” & “No Fault Found” Events in Military Avionic Systems

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Outline

- Background & Introduction
- Turkish Air Force Avionics Testing Results
- Observations from the Field
- Recommendations to Mitigate FAs and NFFs
- Summary
- Conclusions

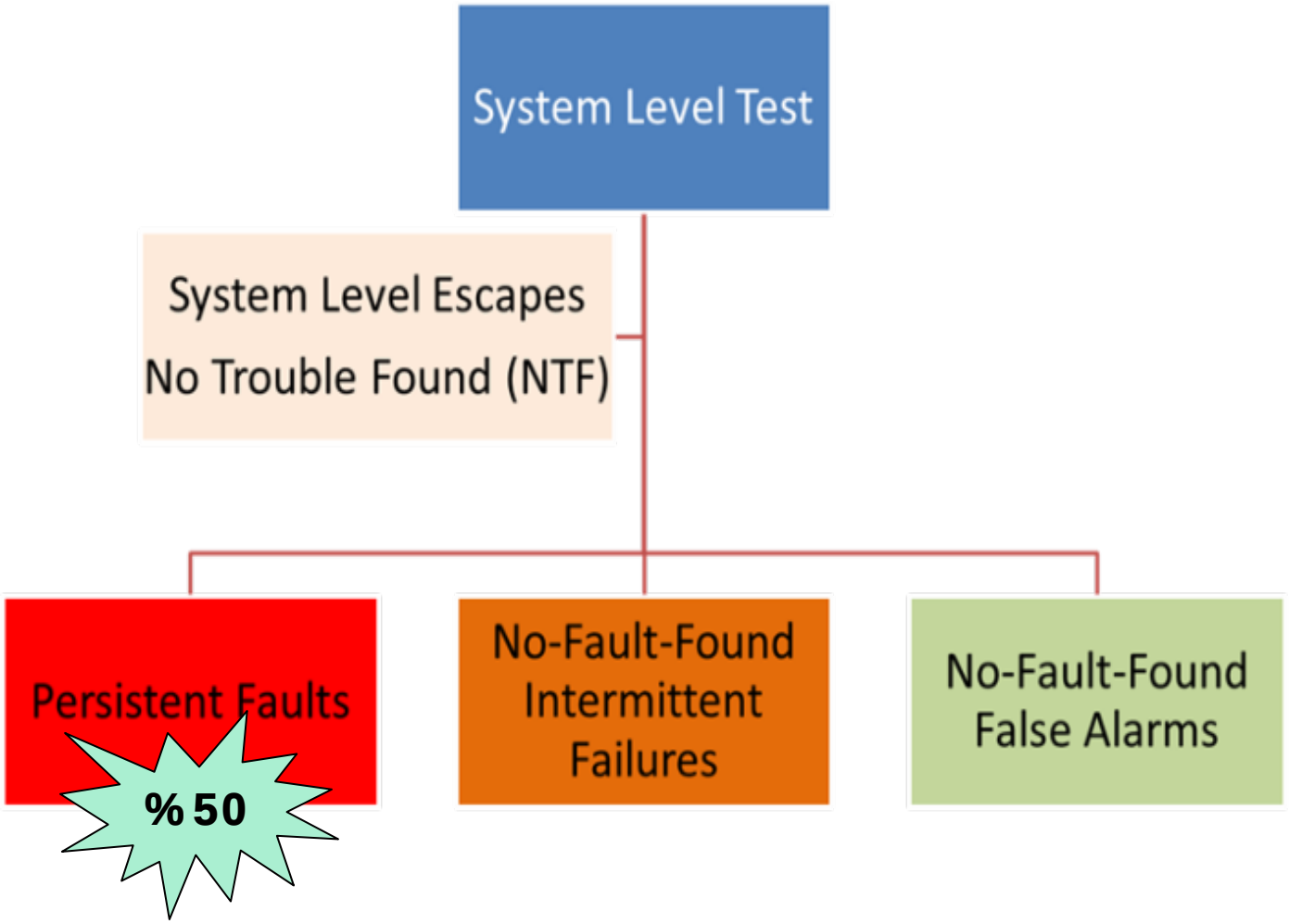
Background & Introduction

- Test professionals are concerned with **finding faults** in a UUT.
- Most TPSs and BIT are considered effective when they find all faults that **exist,**
  - Test quality metrics is generally based on percentage of **faults or failures detected.**
- What happens when **non-existent faults** are found in addition to or instead of existing ones?

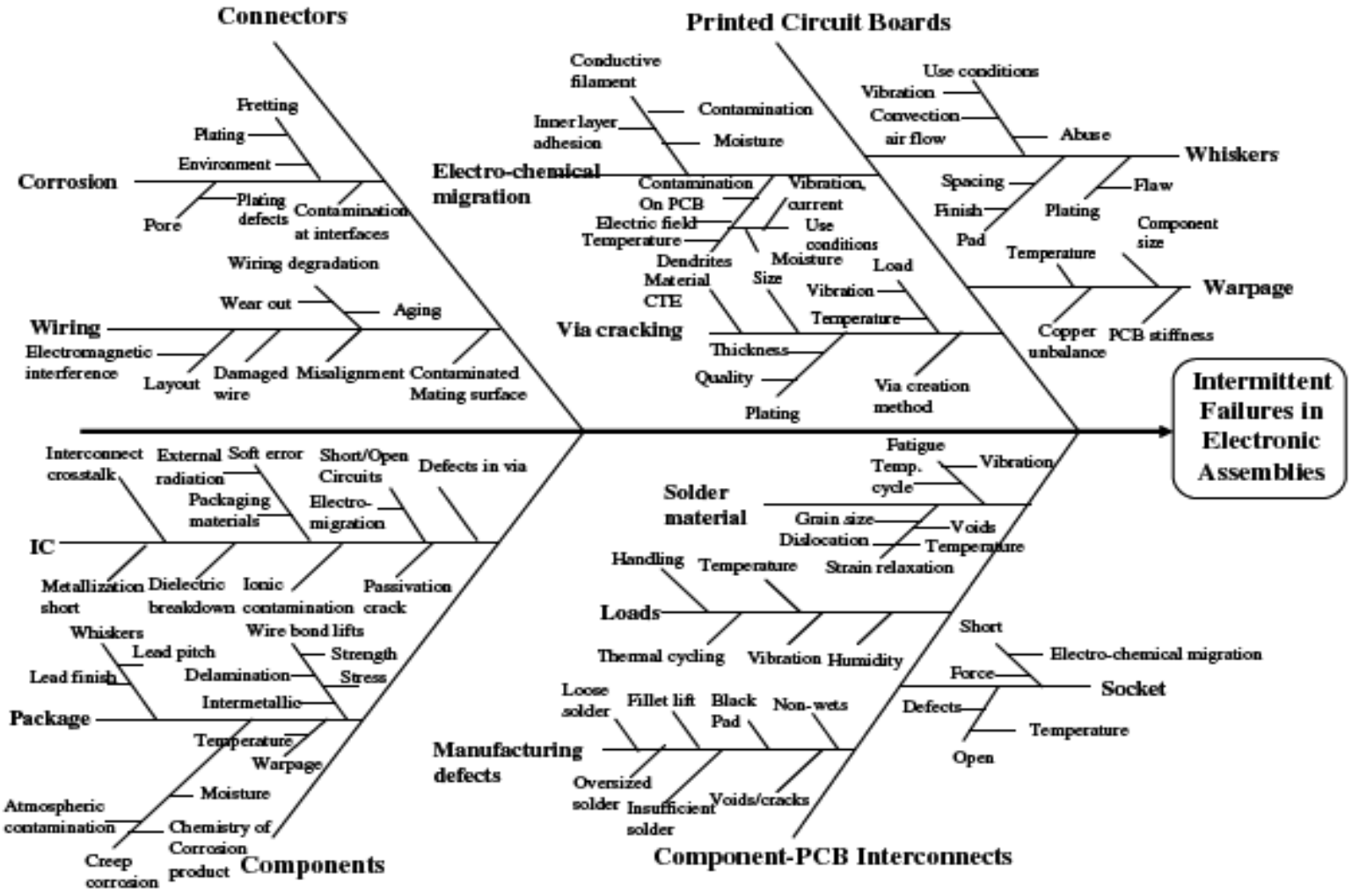
Background & Introduction

- An LRU that is sent for repair is **unwisely** assumed to be faulty.
  - That presumption neglects to take into account other possibilities for the **failure indication**.
- False alarms (FAs) are indications to the **end user** that a failure has occurred when either;
  - It did not occur - generally called FAs,
  - The failure was due to intermittent failures,
  - Inadequate test equipment, test program or test strategy.

Outcomes of Failures @ System Level

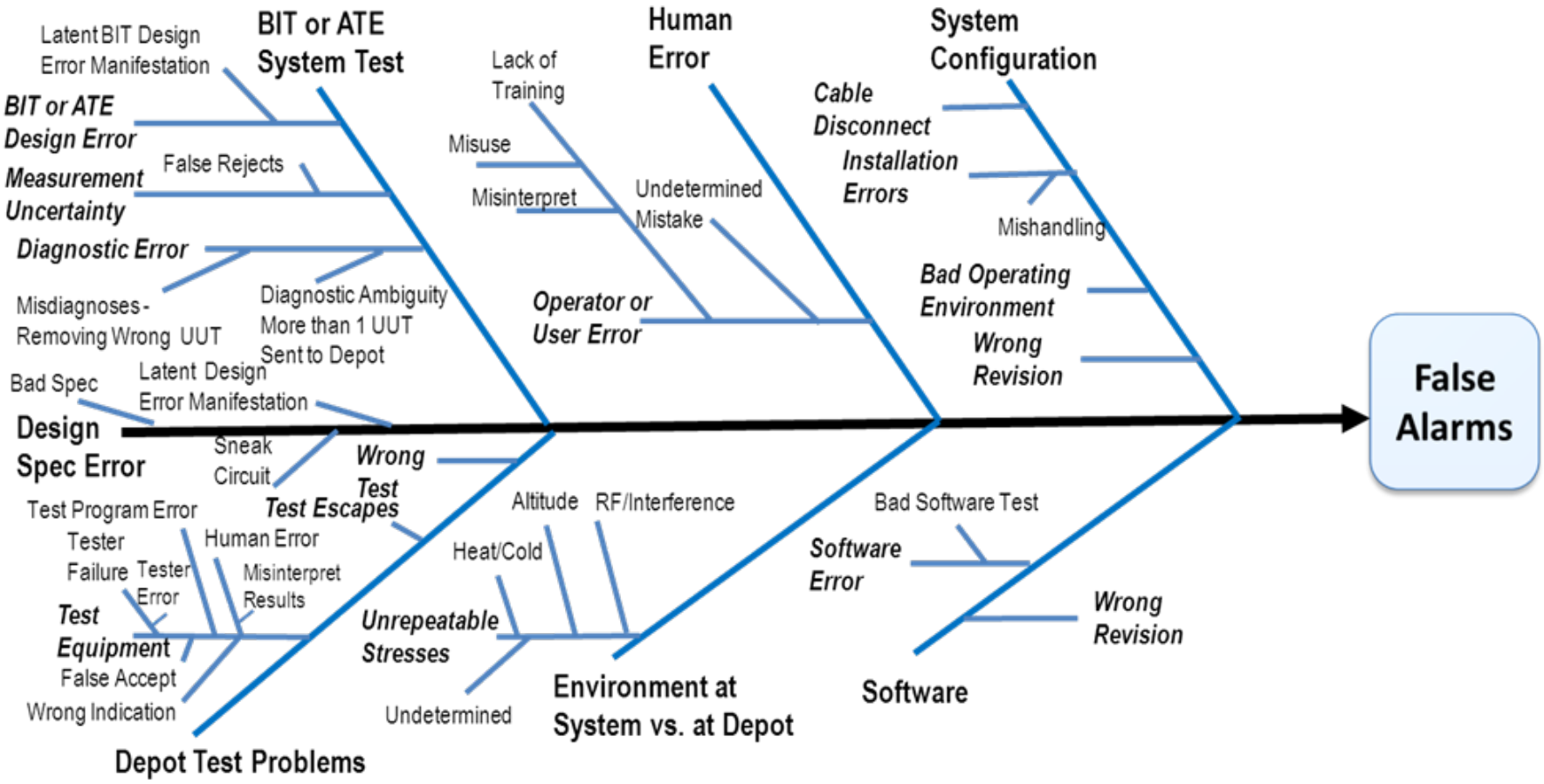


Causes of Intermittent Failures



Source: Qi H, Ganesan S, Pecht M, No-fault-found and intermittent failures in electronic products, 2008

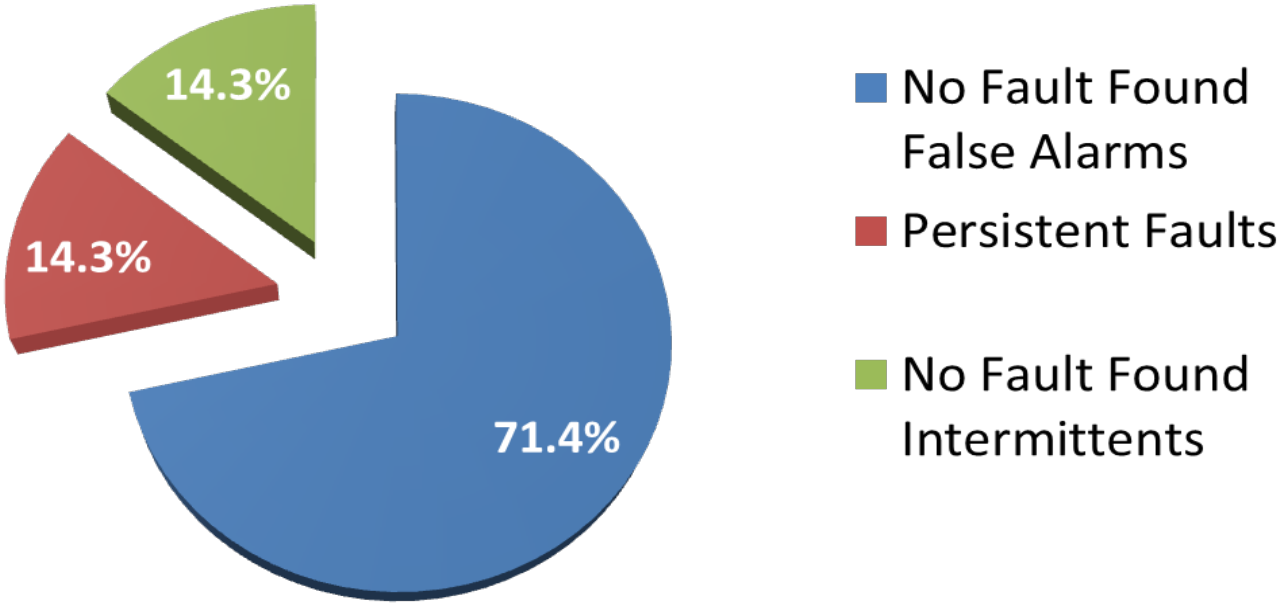
Causes of False Alarms



Louis Y. Ungar, Causes and Costs of No Fault Found, IPC Apex, 2015

False Alarms at O-Level Impact NFFs at I-Level & Depot

Units Arriving at Depot Repair



Louis Y. Ungar, Causes and Costs of No Fault Found, IPC Apex, 2015

Empirical Data Supports this…

- The F/A-18C was fielded with a built-in test (BIT) false alarm rate over 88% and a mean flight hour between false alarm (MFHBFA) rate of less than 1 hour.
  - K. Bain and David G. Orwig, "F/A-18E/F Built-in-test (BIT) Maturation Process," Proceedings of NDIA Third Annual Systems Engineering & Supportability Conference, August 2000
- The V-22 displayed a BIT false alarm rate of 92% during its first Operational Test and Evaluation (OPEVAL) in 2000
  - K. Westervelt, "Fixing BIT on the V-22 Osprey," 2006 IEEE Aerospace Conference Proceedings, 2006
  - K. Westervelt, "Applying the Quality Function Deployment on the V-22 Osprey," 2010 IEEE Aerospace Conference, pp. 1-12, 2010.

From: Russell Shannon and John Knecht, Optimizing Diagnostic Verification Processes, AutoTestCon 2010

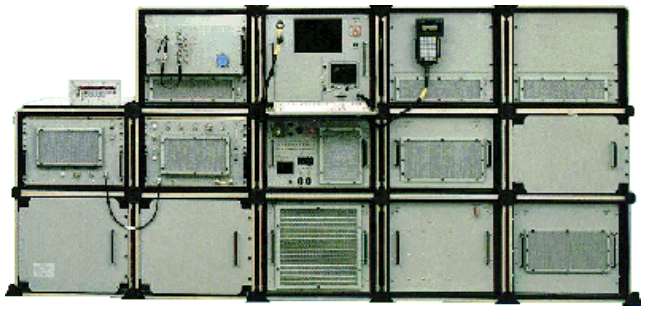
Background & Introduction

- Technicians are confused about NFF;
  - Should they return it to the field?
  - Should they repair it anyway? How?
- The concepts of FA and NFF are complex,
  - The **management** is unable to give proper direction on how to handle it.
- **The decisions made are important financially, operationally and organizationally.**
- Data from the TurAF F-16 avionics maintenance operations analyzed to improve the management of NFF.
  - The lessons learned can save large sums of money, while **maintaining system availability**.

TurAF Avionics Testing Results Avionics Maintenance Operations

F-16 IMPROVED AIS

- TurAF has a large fleet of F-16 aircraft of various types.
- Most of its fleet has gone through an extensive avionics modernization program.
- Each F-16 base, maintenance units have special ATE and TPSs called IAIS (Improved Avionics Intermediate Shop) for the “Intermediate level” maintenance of the F-16 avionics.



TurAF Avionics Testing Results
Avionics Maintenance Operations

- TurAF has adopted a **3-level maintenance concept** for F-16.
  - The flight line, where the LRUs are removed and replaced per the aircraft built-in test (BIT) results.
  - The base or intermediate level (I-level) maintenance where the faulty LRUs are tested automatically by the ATE (named IAIS).
    - Sub-units of electronic cards called SRUs (Shop Replaceable Units) that are removed and replaced.
  - Then SRUs are sent to depot level maintenance where they are tested and repaired by component replacement.

TurAF Avionics Testing Results
Avionics Maintenance Operations

- Many faulty units (mostly SRUs and some LRUs) from TurAF F-16 bases are sent to USA for DLM.
  - Costs more than local repair.
- Most RF LRUs are repaired at HAVELSAN.

NFF Distribution at TurAF

Technology Type	All Returns	NFFs	% NFF
RF	319	94	29,5%
Mixed	232	130	56,0%
Digital	368	175	47,6%
Analog	54	34	63,0%
TOTAL	973	433	44,5%

TurAF Avionics Testing Results Observations from the Conference

Management Perspective of NFFs

- NFF is a regular part of the avionics maintenance.
- While the technicians cannot fix NFFs, they need guidance on how to deal with them.
- The TurAF F-16s may be experiencing less NFF than others;
  - Costs are amplified when units have to go to the USA for repairs.
  - There is a natural pressure on repair technicians to fix the problem.

TurAF Avionics Testing Results Observations from the Conference

Management Perspective of NFFs

- Improve contact with vendors and USAF depot.
- AIS technicians to take more time and be specific when filling the forms.
- All AIS shops requested full serviceable set of avionic LRUs.
  - Indication of experiencing high NFF rates and having difficulty to troubleshoot and isolate to the faulty SRUs.

Observations from the Field

Technicians Dealing with NFFs

- `**Golden units**` used as reference.
- No "**bad actors**" reported.
- **'Zero tolerance'** policy for avoiding serious maintenance problems – abort, repeat
  - Shot-gun maintenance
  - Label the LRU as NRTS.

Observations from the Field

Technicians Dealing with NFFs

- NFF is the norm rather than the exception.
- Ambiguity on the aircraft results in removal of multiple LRUs.
- Come back as NFF or as fixed based on technician`s experience due to "**repeat pressure**"
- Increase the NFF rates at the depot.

Observations from the Field

Technicians Dealing with NFFs

- Web-based data base program.
- Make suspect LRUs as NRTS
- Avoid repeat/abort type problems.

Observations from the Field

System Managers Dealing with NFFs

- NRTS reduces stress on the local managers and the technicians.
- Increased financial toll for TurAF.
- Then, the system managers at ALC are under pressure
- Send the units to other AIS shops.
- Make sure that the LRU is really faulty.
- Its serviceable parts used for “shot-gun maintenance” and “cannibalization”.
- Reason for heavy cross-service LRU traffic.

Mitigating FAs and NFFs @ the Flight Line & Beyond

Wholistic Approach

- Use System Level BIT to reduce FAs - DFT
- Ensure specs agree with operation
- Reduce operator error with better training
- Reduce system configuration errors
- Expect and mitigate software errors
- Expect and monitor environmentally induced failures
- Improve fault isolation to a single LRU close to 100%

Mitigating FAs and NFFs at the Shop

- The prevailing policy of the TurAF calls for not to attempt to repair NFFs by overenthusiastic technicians.
- Train technicians on NFFs
  - Expect NFFs as a natural phenomenon
  - More telling way to document the occurrences of NFFs
  - “Repeat pressure” should not lead to unnecessary repairs
- The management needs to know that technician alone has no power to avoid NFFs and very little power to “fix” it.

STOP BLAMING THE TECHNICIAN..!

Summary

- NFF is not a new problem but still largely unsolved and affecting all kinds of a/c.
- FA and NFF data from the TurAF F-16 are lower than others.
  - May be at the expense of increased costs.
- NFFs are complex and technicians should not be in a position to have to deal with them.
  - Technicians should not be the ones to suffer or be punished for NFFs,
- 'Replacement' is not the solution and '**Pressure**' hinders the real progress towards solution.

Conclusions

- **TRAINING for All.**
- Better Communication between the maintenance levels.
- Look outside the avionics maintenance shop.
- FAs and diagnostic ambiguity are main contributors and hence more focus should be placed on the system on flight line & beyond.
  - LRU supplier and BIT on the aircraft
  - System Integrator
  - Design for Testability
- 777 & 787 programs are cited as good examples.

NFF Studies…

- ADS MRO&L NFF Working Group
  - Prof. C J Hockley – Cranfield Uni.
  - Mr. Ian James – Rolls Royce
  - Mr. G M Gilles Huby – Copernicus Tech. Ltd. (https://www.linkedin.com/pulse/maintenance-problem-measured-billions-giles-huby)
  - NFF symposium (June 2017)
- Mr. Louis UNGAR – ATE Solutions Ltd. (https://www.linkedin.com/pulse/false-alarms-well-intentioned-killers-louis-y-ungar) www.besttest.com/
- Mr. Brent Sorensen – Universal Synaptics Corp. www.usynaptics.com
- IEEE AUTOTESTCON, ITC conferences

Thanks for listening..!

Dinlediğiniz için Teşekkürler..!