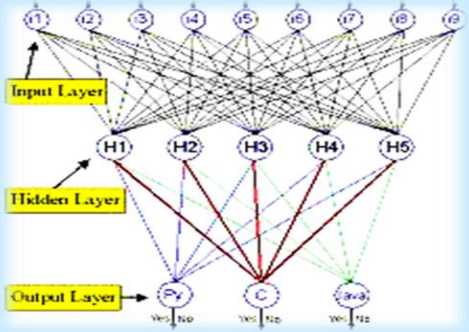
# Using Neural-Network Test Technology for Avionic Systems Maintenance

***From This***




***To***

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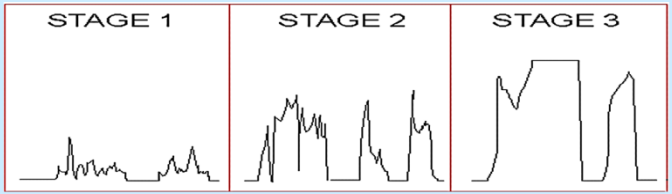
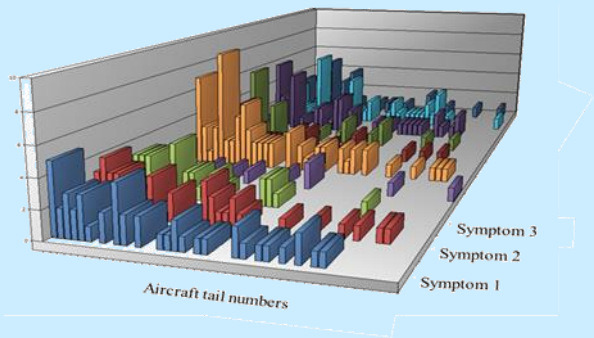
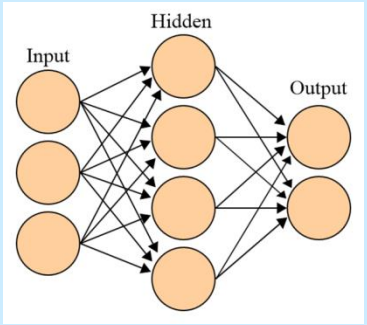
# How……





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# & Why……

**Repeat Faults**

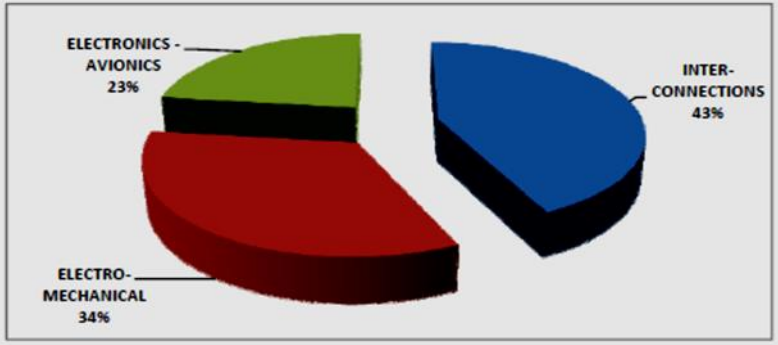


**Figure 4- Occurrences of Electrical Failures by Classification[3].**



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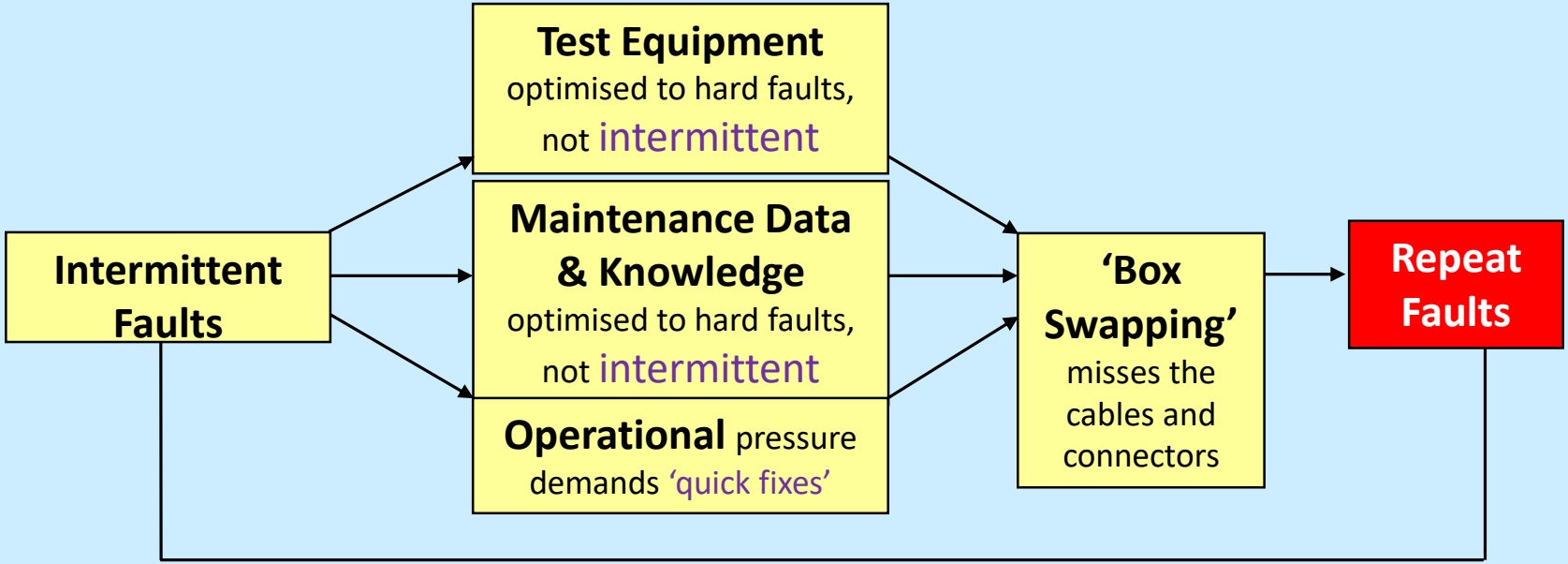
# The Cause





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# Sustainment

- The Heavy Airlift Project Office worked with HALSPO to establish the C-17 sustainment capability **by joining the USAF-led Globemaster Sustainment Partnership (GSP),** …….establishing numerous other specialist supply chains for aspects including life support equipment, mission planning systems, training, self-protection systems and satellite communications services. Defence Annual Report 2008-9

- My Interpretation: Line Replaceable Units are normally returned to the OEM for test and repair.

- No Fault Found returns consume **assets, time and funds.**


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# OEM Maintenance Manual


Support documentation is thorough for “hard” faults but is unable to address the symptoms of every intermittent fault


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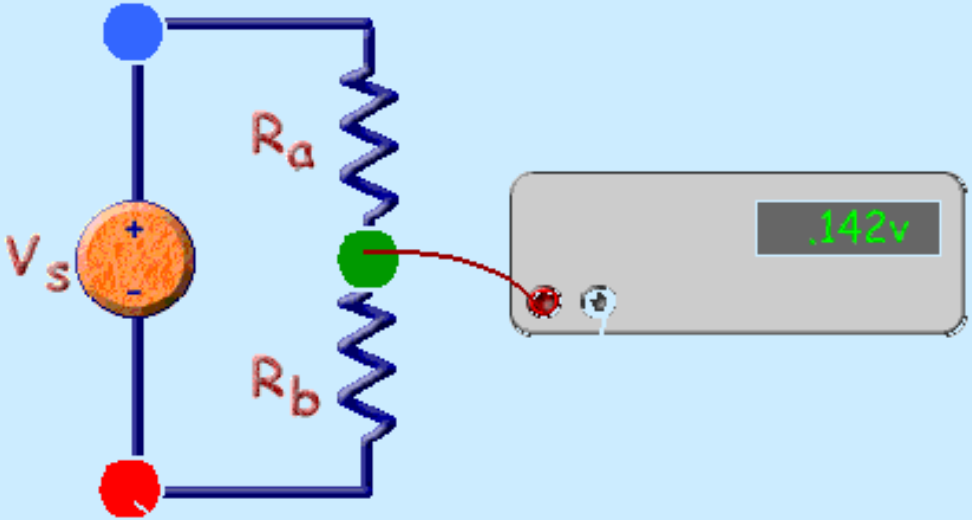
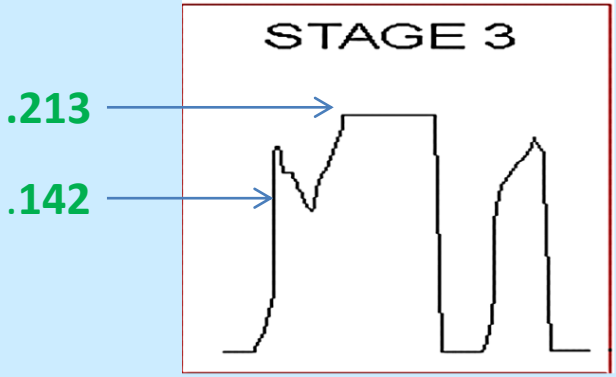
Conventional Test Equipment **AVERAGES** values
And looks like…….




What DO I need to measure it accurately?…….




***Something that captures the glitch***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# Narrow the Search……

| DSAS_ID | Reference_D | Full_IdentR | KeyRunHr | yInputSente | MRC_No | Symptom | inal_Part_Des | eviewed_Par | SerNos | Activity | alDescriptio | al_Hours_W |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1387 | 03-Aug-11 | ABC024 | 6272 | Fix | 1966 | CORRUPTED TEXT AT TOP EDGE OF DISPLAY | Display | NV-15927-55- | R(?) -(?) +(?) | Repair | | 0.75 |
| 2064 | 04-Aug-11 | ABC024 | 6275 | Fix | 3355 | MESSAGE GARBLED TOP EDGE DISPLAY | Display | NV-15927-55- | R(NONE) -(?) | Repair | display | 3.5 |
| 2065 | 06-Aug-11 | ABC024 | 6277 | Fix | 3365 | CANNOT READ TOP EDGE TEXT | Display | NV-15927-55- | R(NONE) -(?) | Repair | display | 4.2 |
| 2066 | 08-Aug-11 | ABC024 | 6281 | Fix | 3378 | LETTERS GARBLED DISPLAY TOP | Display | NV-15927-55- | R(NONE) -(?) | Repair | display | 5.1 |
| 2067 | 12-Aug-11 | ABC024 | 6290 | Fix | 3382 | SYMBOLS INSTEAD OF MESSAGE DISPLAY TOP | Display | NV-15927-55- | R(NONE) -(?) | Repair | display | 2.2 |
| 2068 | 14-Aug-11 | ABC024 | 6295 | Fix | 3389 | DISPLAY WORDS MISSING | Display | NV-15927-55- | R(NONE) -(?) | Repair | display | 1.5 |
| 2069 | 16-Aug-11 | ABC024 | 6297 | Fix | 3395 | NO WORDS DISPLAYED TOP EDGE | Display | NV-15927-55- | R(NONE) -(?) | Repair | display | 1.7 |
| 1488 | 09-Sep-11 | ABC024 | 6380 | Not Rectified | 5031 | BRIGHTNESS CONTROL INOP | Display | | R(NONE) -(?) | Functional | full functional | 2.75 |
| 1501 | 12-Sep-11 | ABC024 | 6383 | Fix | 6383 | BRIGHTNESS ON DISPLAY U/S | Display | NV-15927-55- | R(NONE) -(?) | Repair | display | 2.75 |
| 1693 | 12-Nov-11 | ABC024 | 6479 | - | 6479 | SCREEN IS TOO DARK | Display | | R(NONE) -(?) | | | 2.75 |
| 1586 | 21-Dec-11 | ABC024 | 6444 | Fix | 6444 | DISPLAY NOT BRIGHT ENOUGH | Display | NV-15927-55- | R(NONE) -(?) | Repair | Display | 2.75 |
| 1914 | 13-Apr-12 | ABC024 | 6652 | Fix | 6652 | DISPLAY NOT BRIGHT ENOUGH | Display | NV-15927-55- | R(NONE) -(?) | Repair | display output | 2.75 |
| 2041 | 03-Jul-12 | ABC024 | 6751 | Fix | 5102 | DIM DISPLAY | Display | NV-15927-55- | R(NONE) -(?) | Repair | display | 2.75 |


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# System Commonality

Every Airbus A380 has

**100,000** Wires totalling **530** km,

with each loom terminated in a connector*.


* New York Times
11th December 2006



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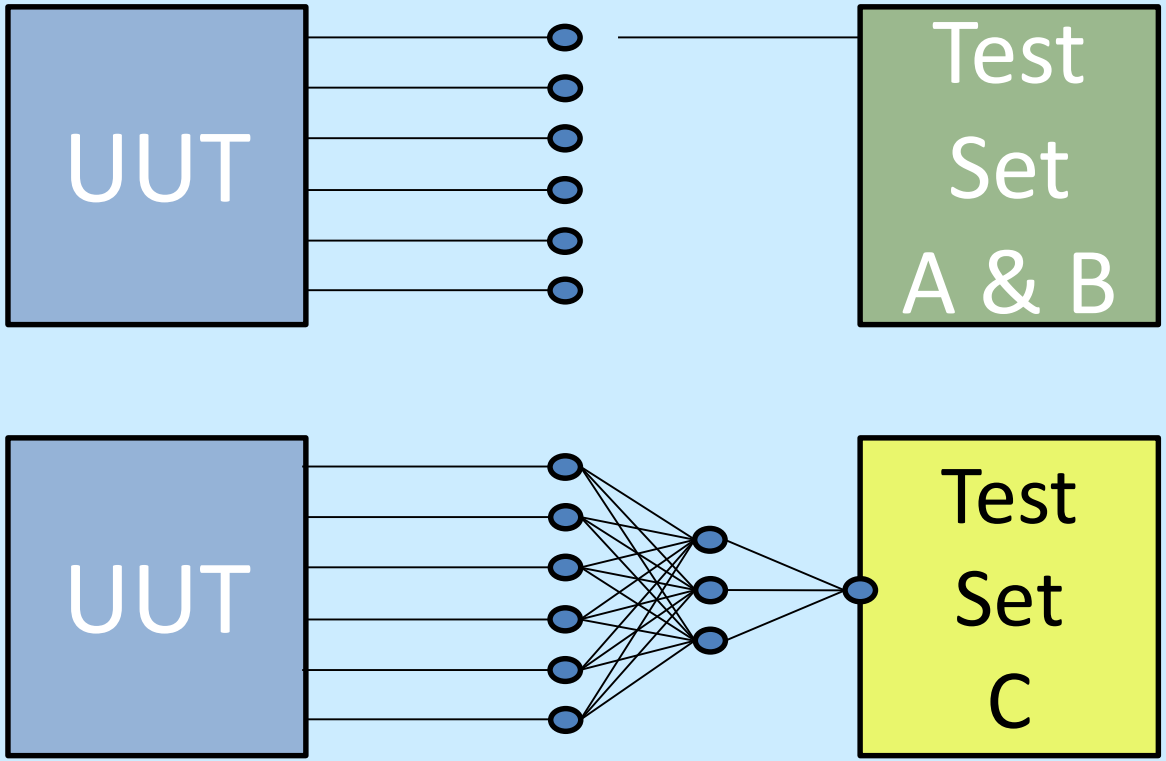
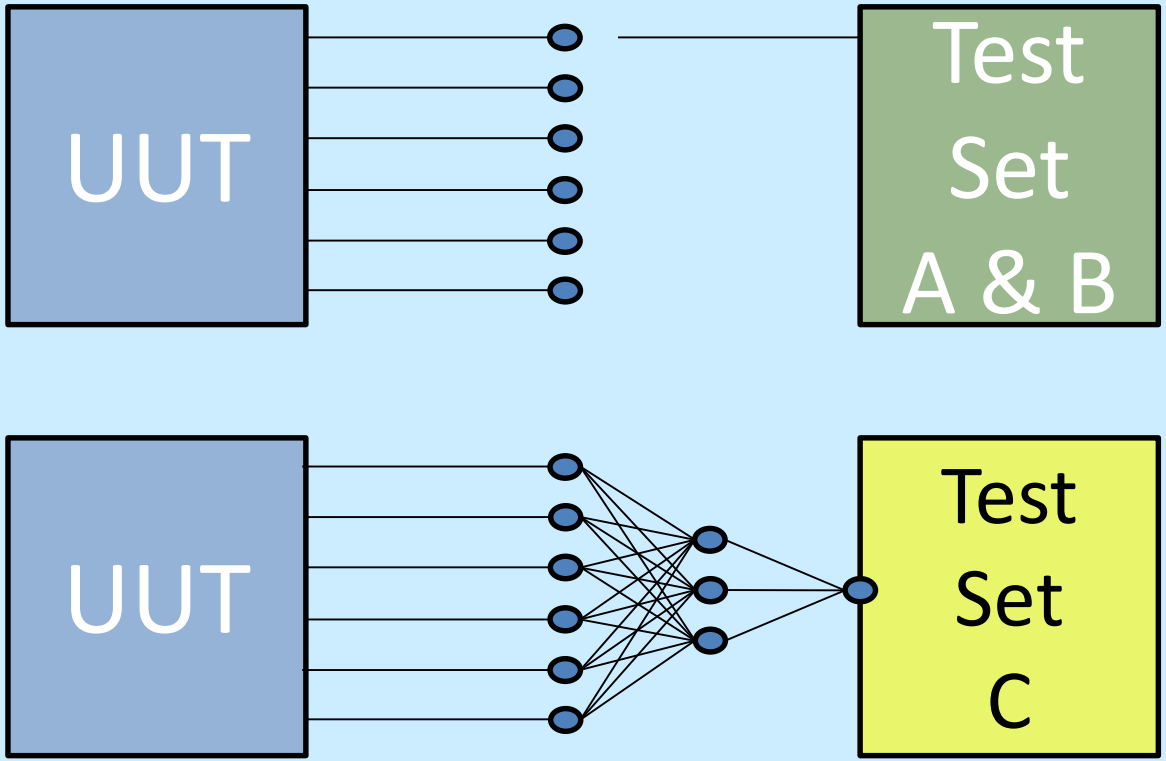
**Detection Simulation**: Probability of Detection

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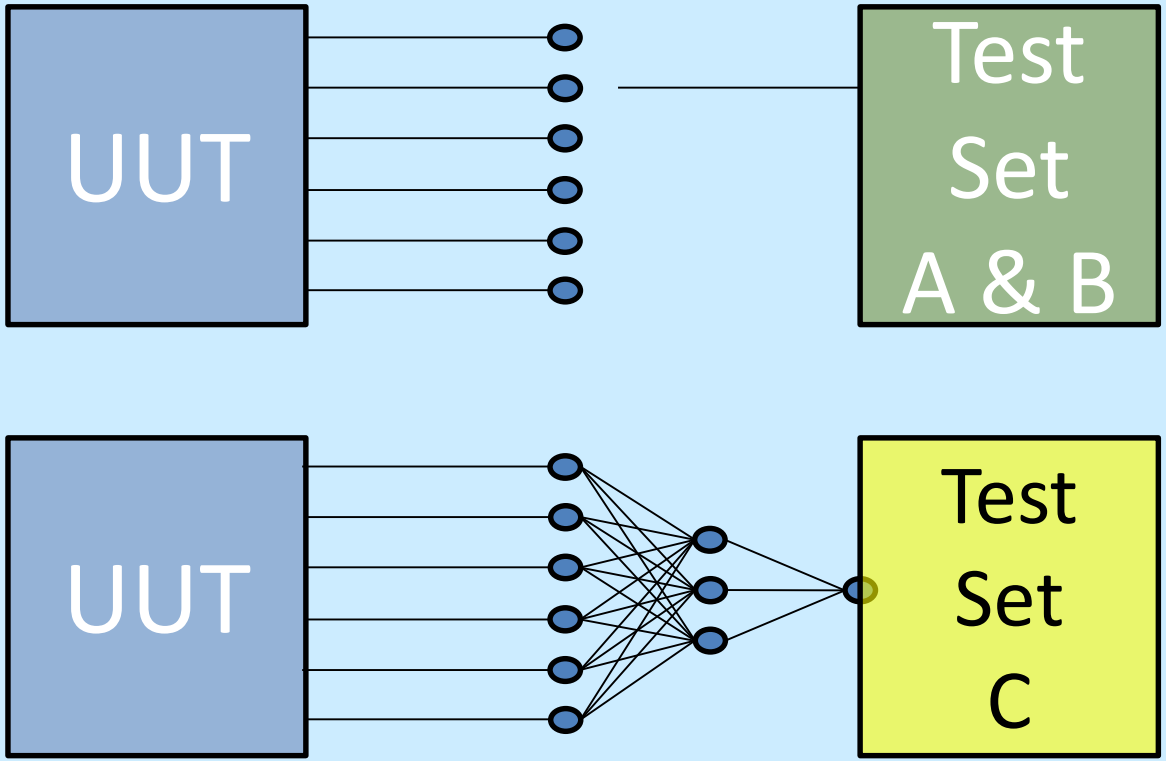
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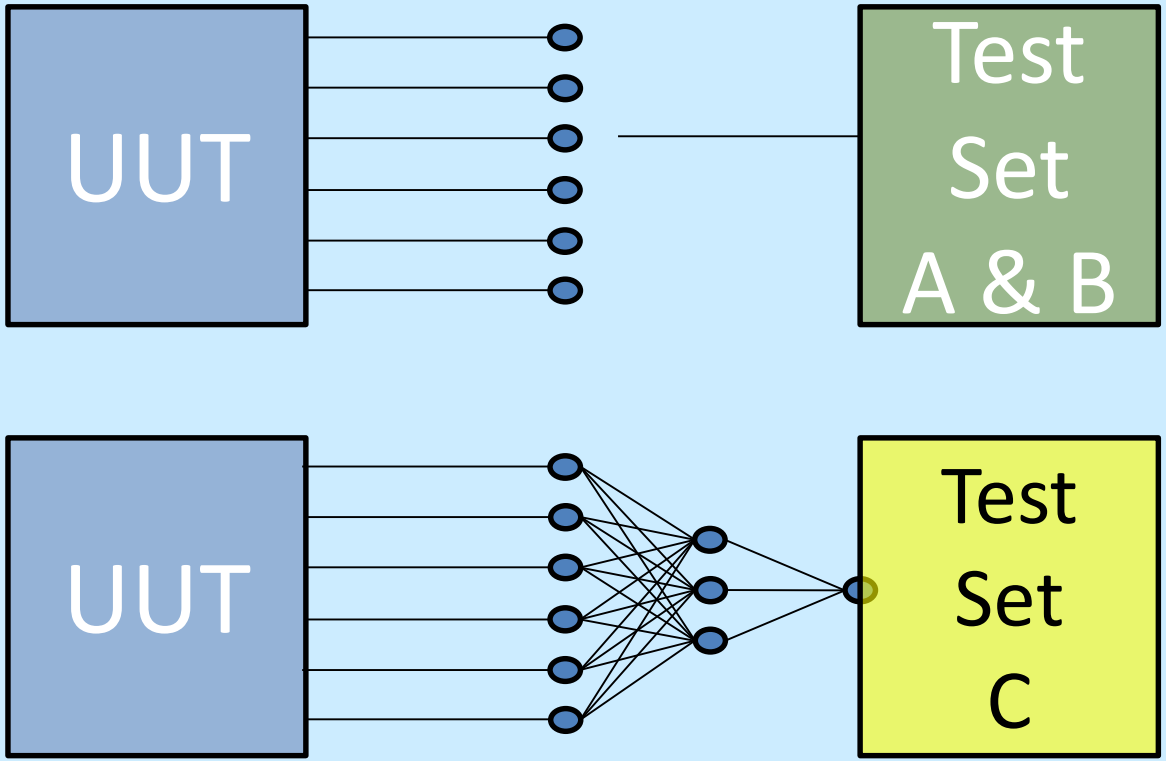
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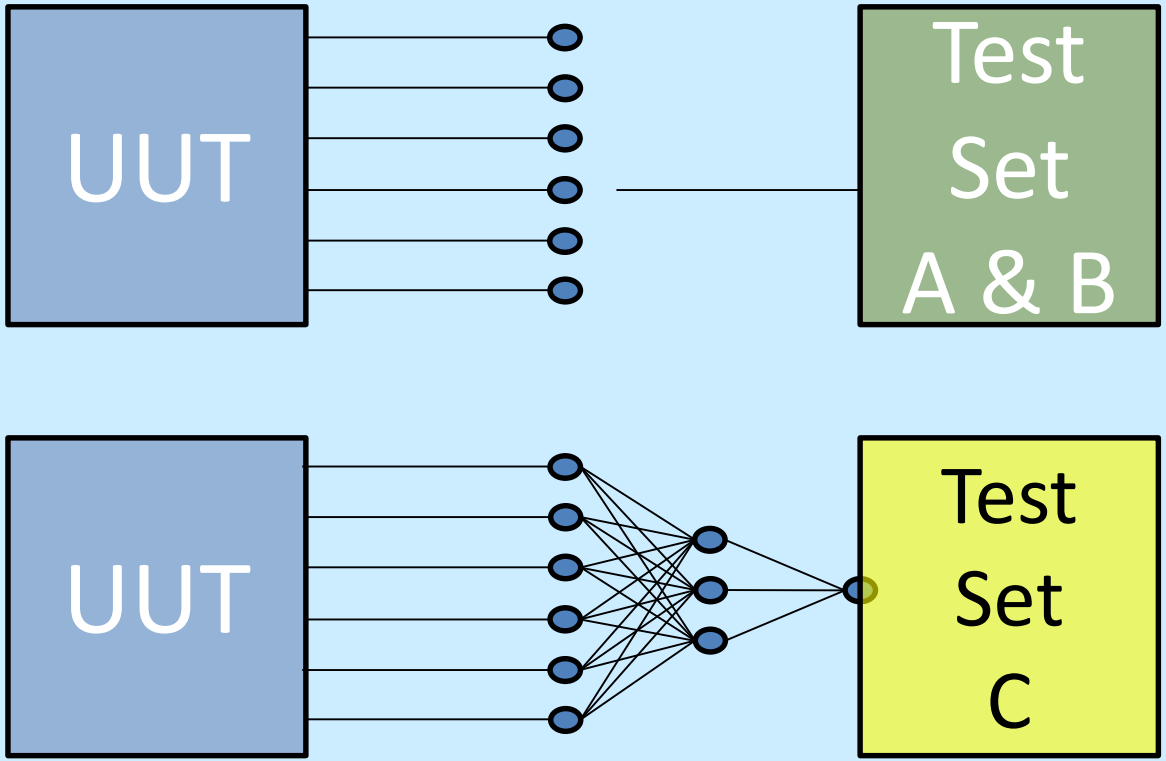
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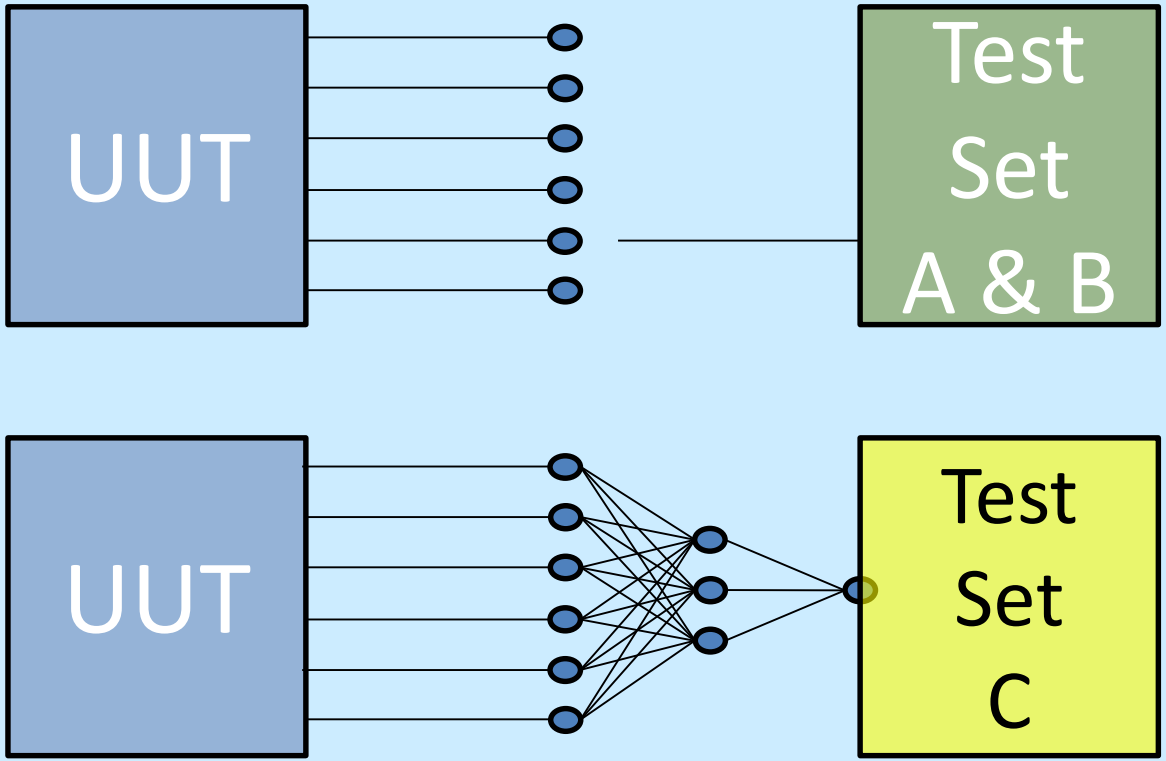
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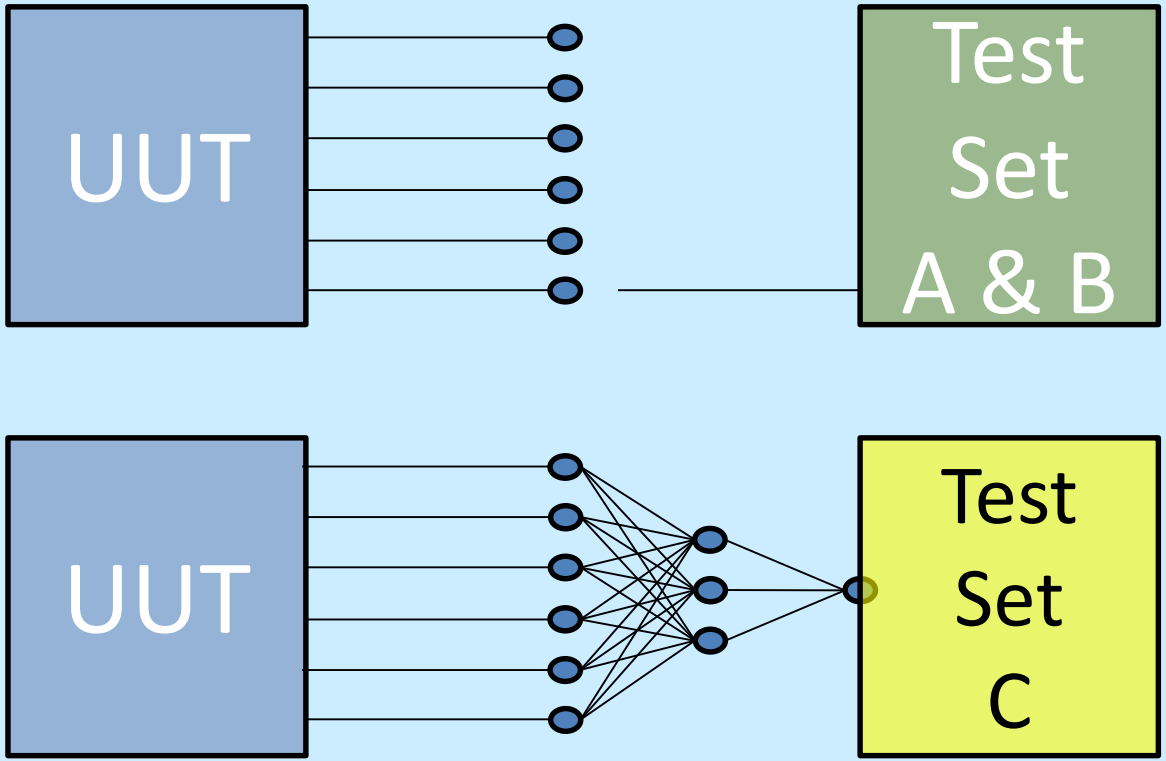
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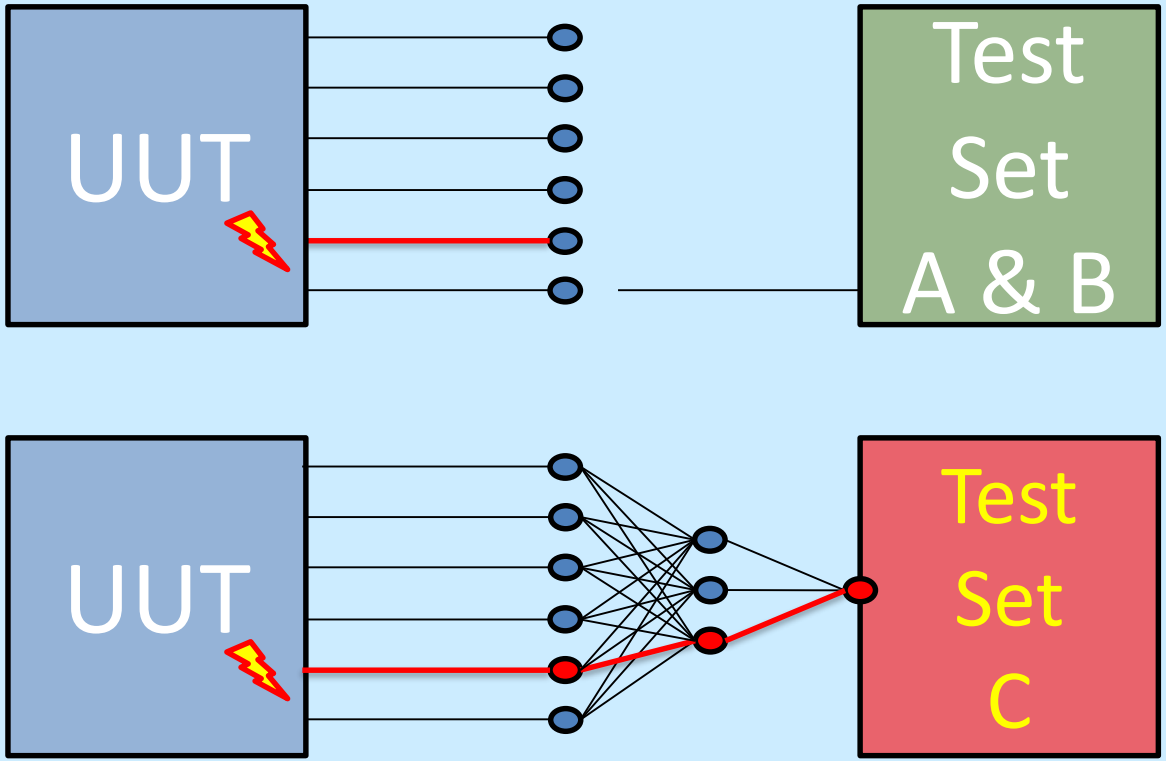
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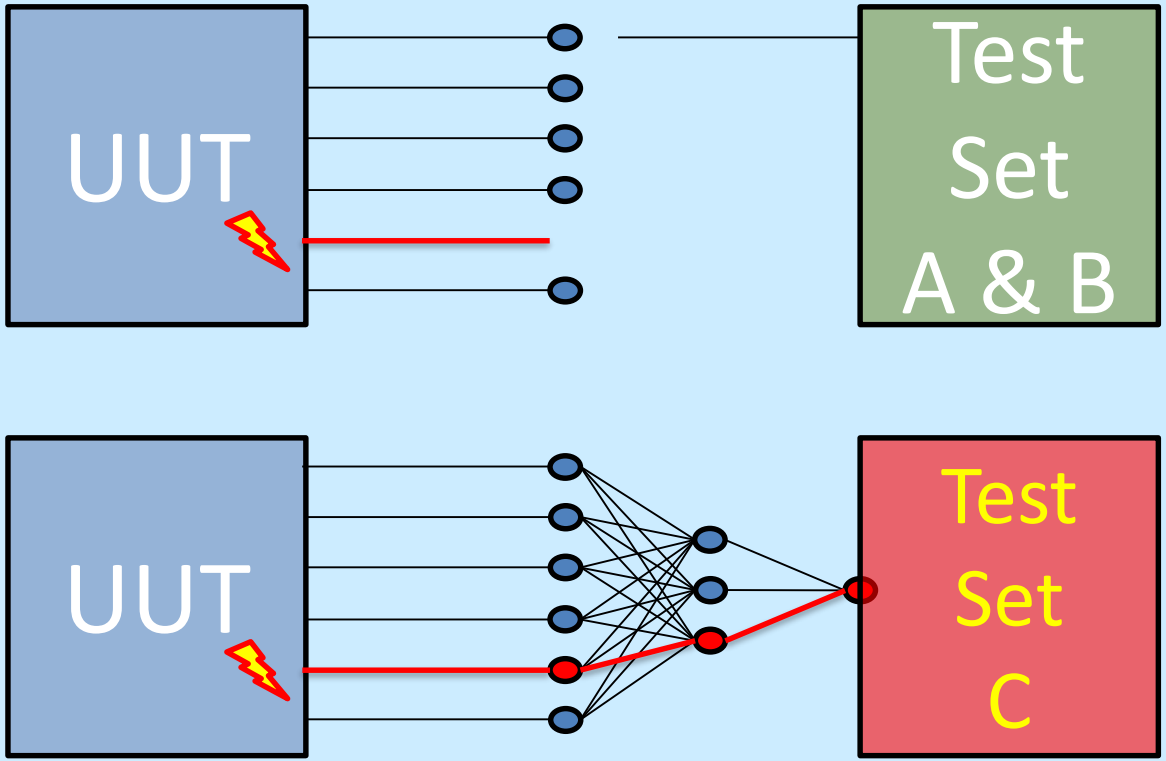
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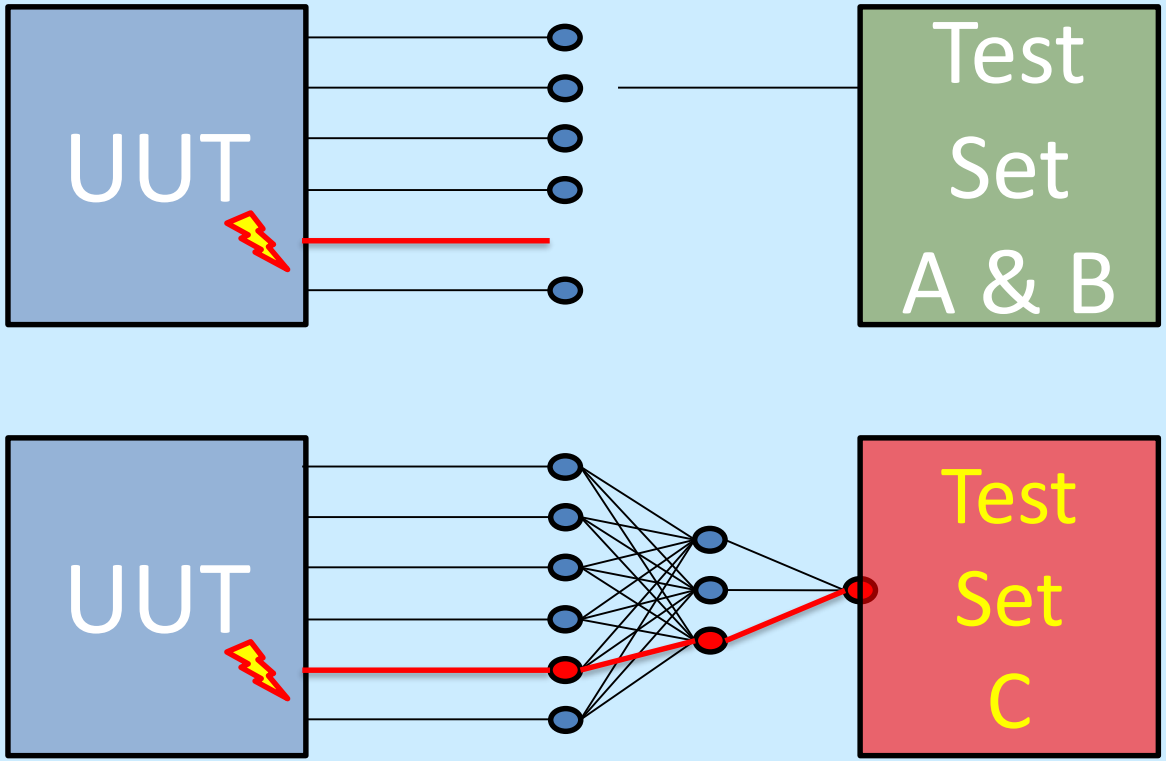
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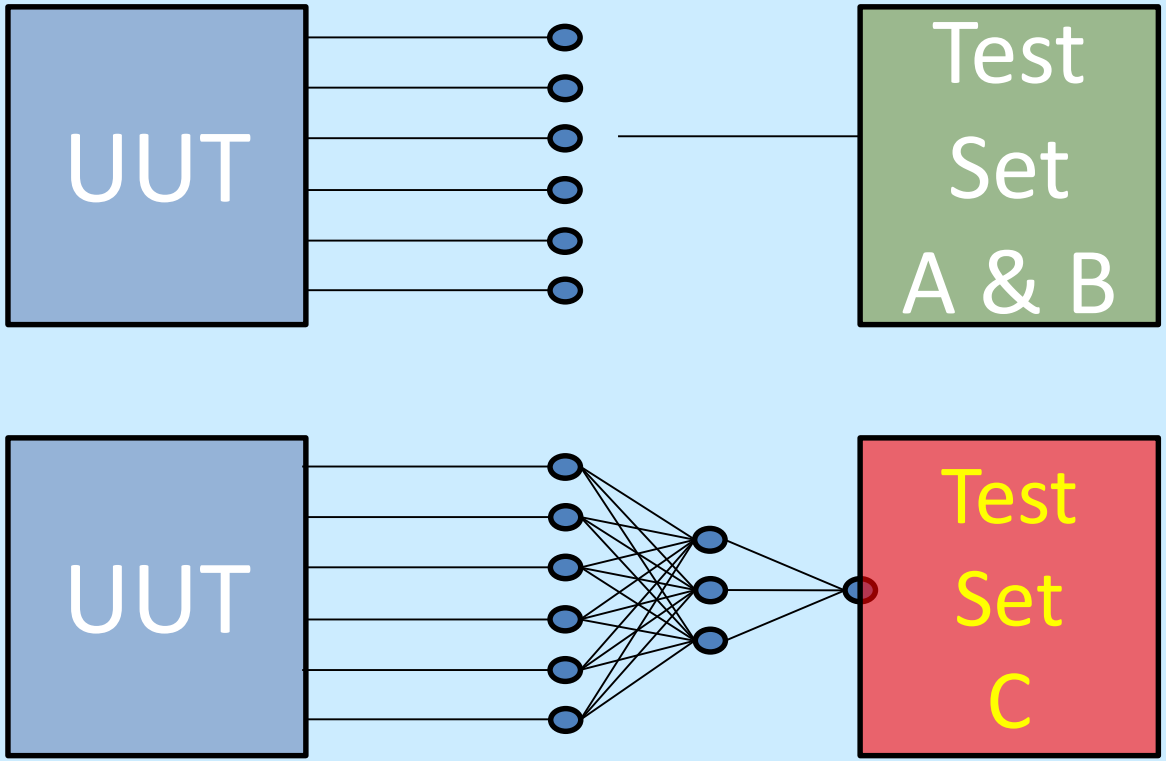
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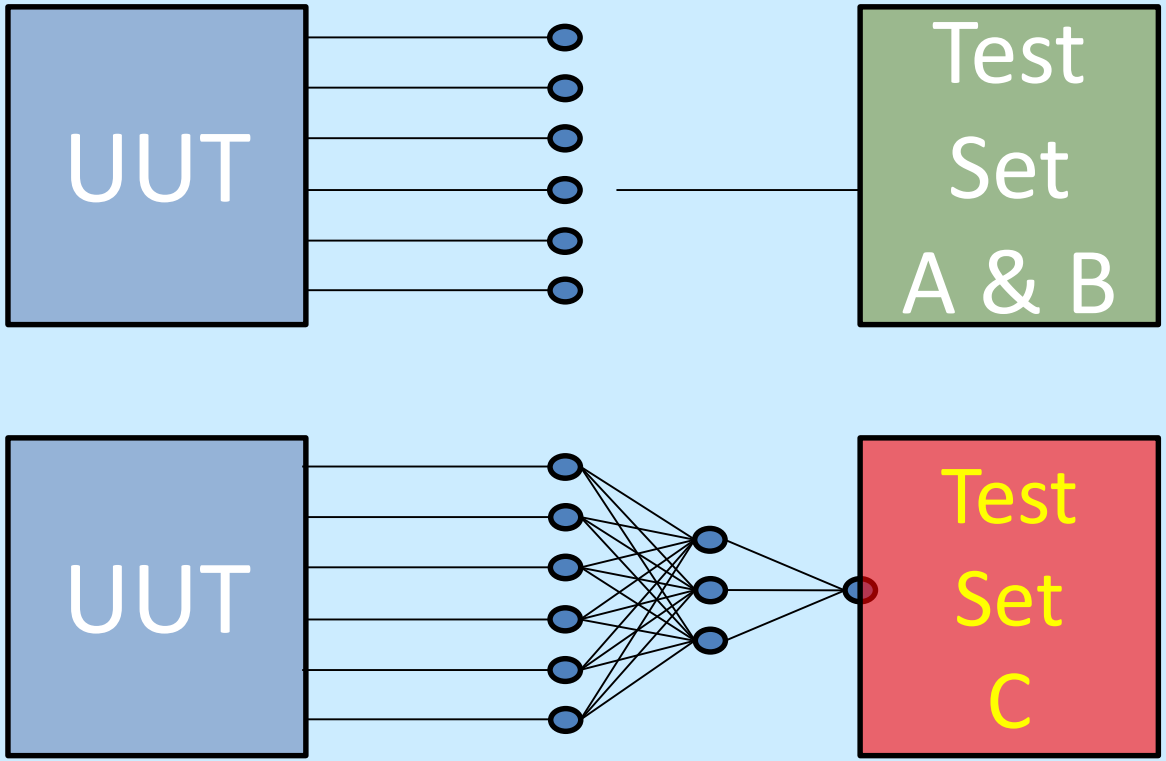
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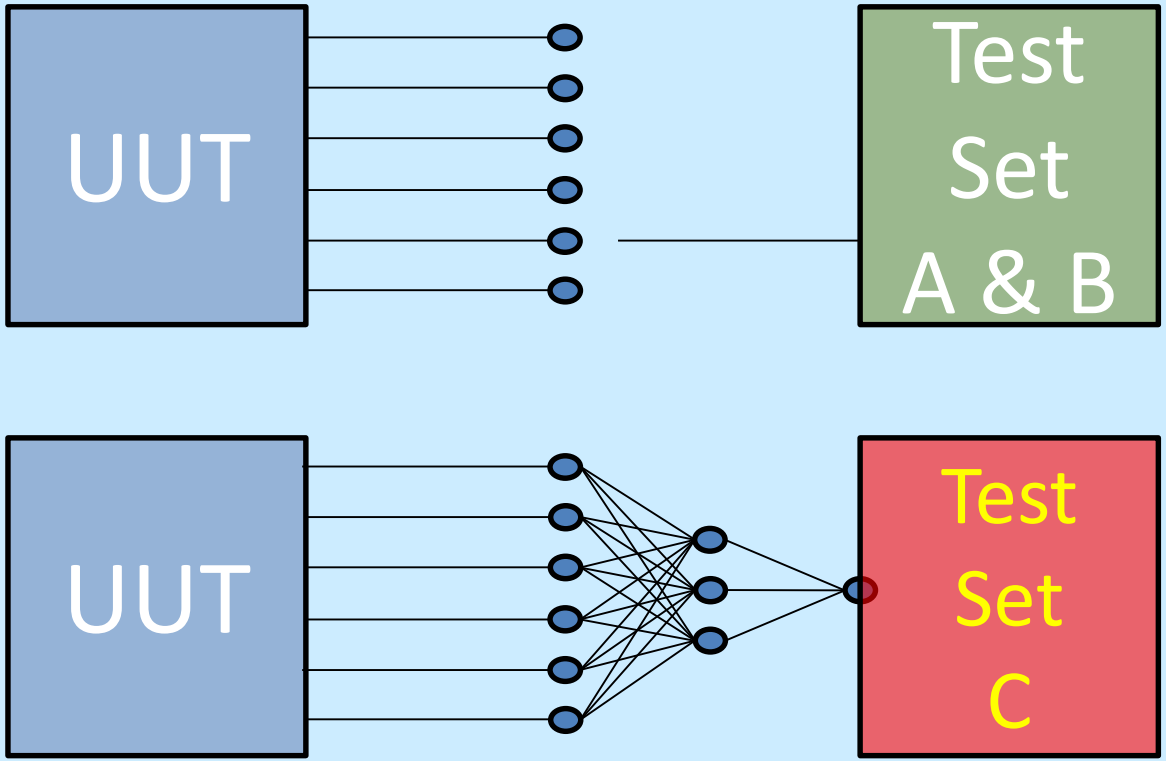
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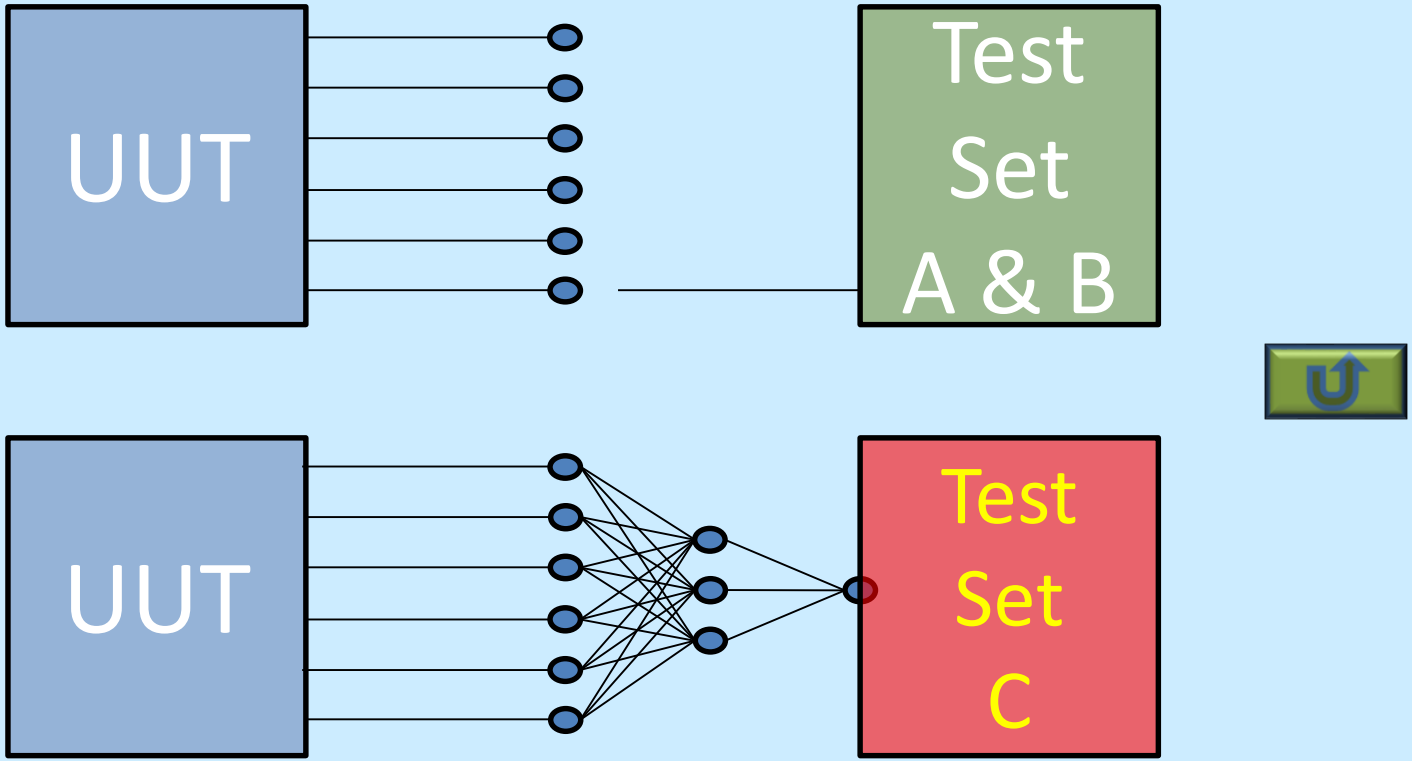
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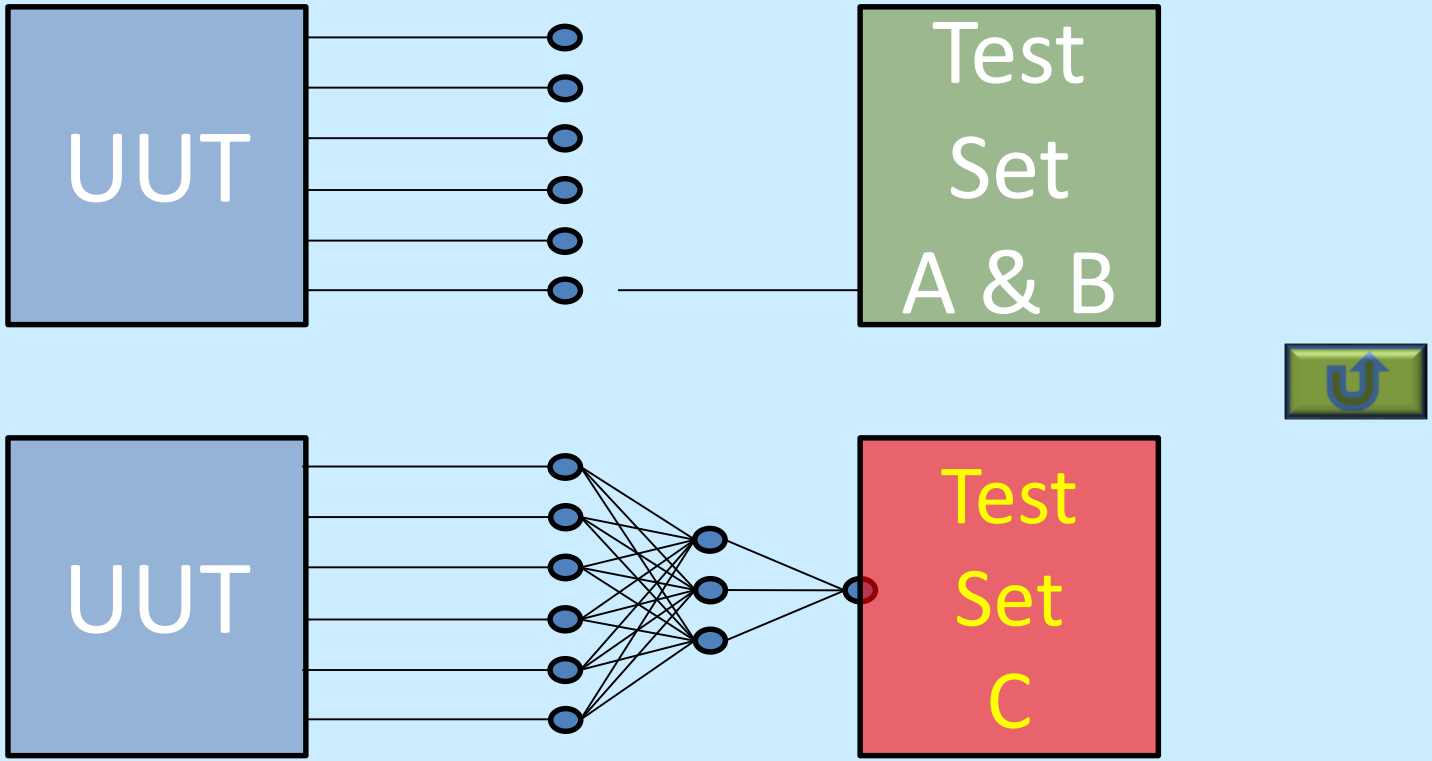
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# How to use the Capability


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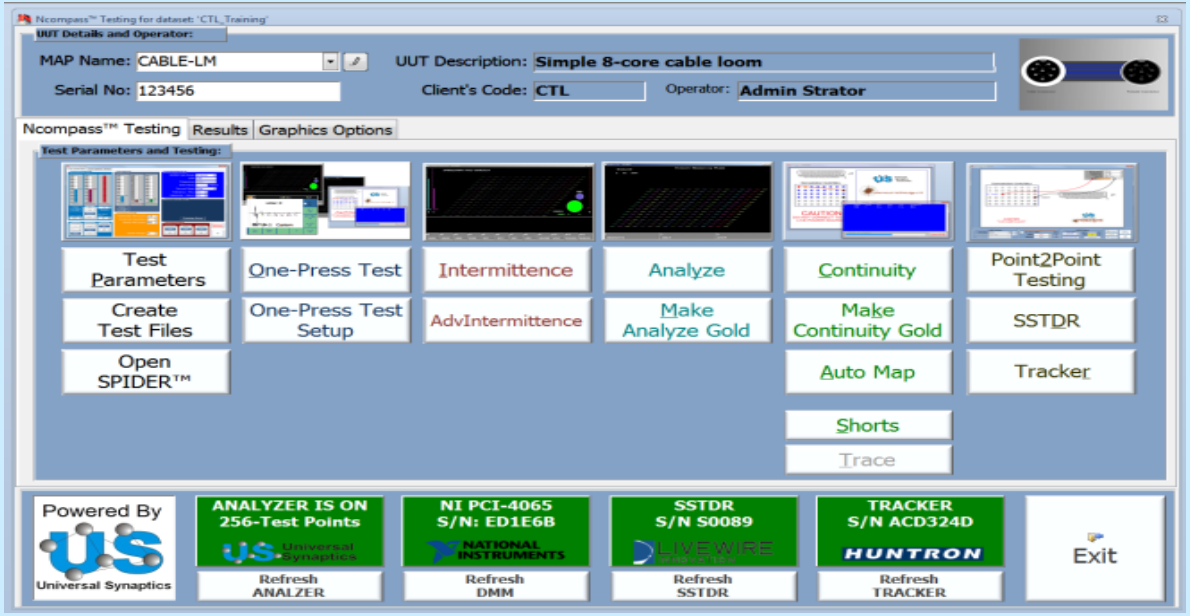
# Test Functions





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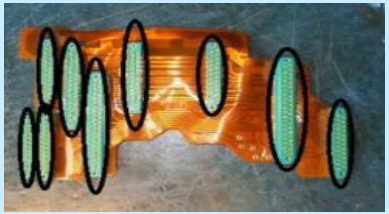
# Step 1: Select Unit Under Test



## You don't need to test everything

Use repair data to select candidate test items on a criticality basis eg

- Safety-critical
- Performance-critical
- Known 'high hit' items

Copernicus Technology has a criticality analysis tool for this task.

Some component/harness will need testing on a regular basis

Others will be one-off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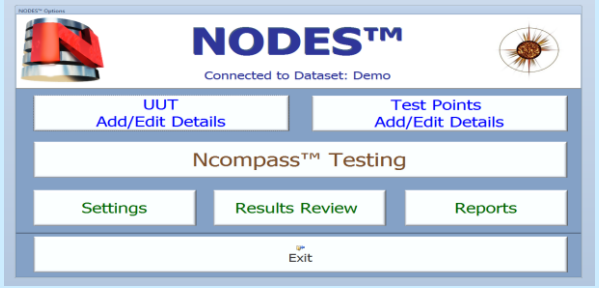
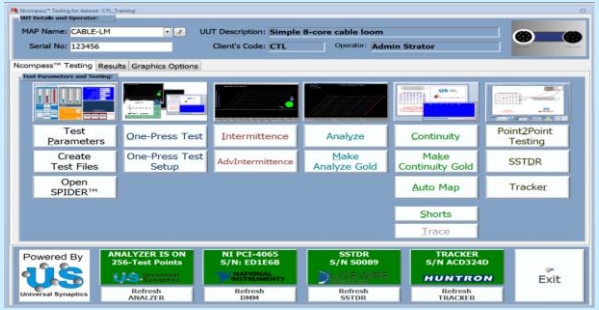
# Step 2: Test Configuration




Identify which tests need to be carried out eg Continuity + Intermittency.

For a one-off : use a generic Interface Adapter (IA) and AutoMap™ to set-up the test configuration.

If the test may be a regular occurrence then set up test point connections data in the NODES user interface software.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# Step 3: Interface Adapters

If testing is repetitive then design and build Interface Adapters: assisted by NODES GUI

Construct IAs using relevant connectors corresponding to the test point connection data from Step 2

**If other test adapter cables are available then use a 'patch cable' to connect the Voyager via the those items**


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# Step 4: Testing








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# Test Accessories


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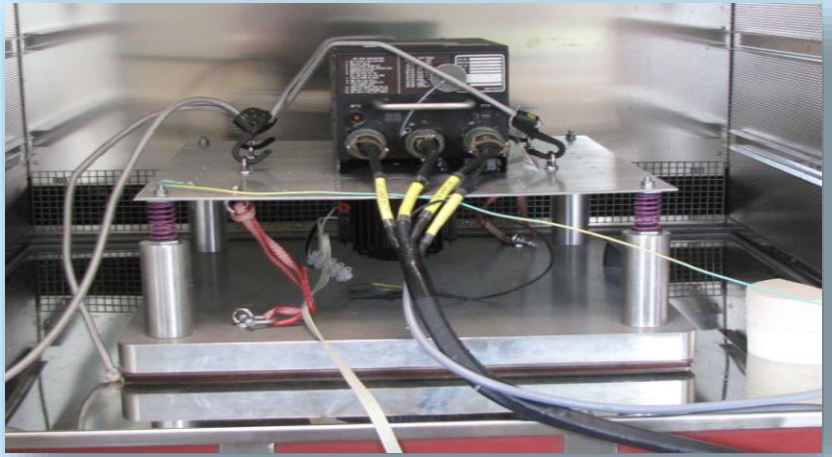
# Break-Out Box

## Mobile Vibration System

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# FAQs - What can it test?

- Ncompass-Voyager's range of test functions mean that they can be used to benefit an extensive range of production and maintenance scenarios.
- Electrical and electronic integrity faults of down to 50 nanoseconds can be detected and isolated and the subsequent test results can be used to characterize the fault in the following types of 'Unit Under Test' (UUT):
  - **EWIS components (CBs, relays)**
  - **Wiring harness and connectors**
  - **Ribbon-cables**
  - **Back-planes**
  - **LRU external and chassis interconnections**
  - **PCB connections**
- Faults are rapidly detected and isolated, including distance-to-fault.
- Test results data can also be used prognostically for evidence-based decision-making

# FAQs - Will it need lots of interface adapters?

- Interface Adaptors are links between LRUs and the Ncompass Voyager D-sub connectors.
- You don’t need to test everything; analyse which wiring harnesses/components cause the most pain in terms of NFF and repeat arisings then focus on them.  Tools are available.
- You may have IAs from other types of wiring testers (ie, DIT-MCO), connect using those.
- For “one-off”, tests there are generic IAs available to suit eg with standard connector types or with standard pins on flying leads.
- Once you’ve got a Special To Type Interface Adaptor, you can then carry out rapid, repeatable and standardised testing as often as you like: one-button testing is available.


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# FAQs - Who sets up the Test Configurations?

- The Test Program Sets (TPS) for Ncompass-Voyager testers comprise the Interface Adaptors and the Unit Under Test configuration on the NODES GUI
- Testers are pre-configured with customer-specified Unit Under Test set up on NODES and with Interface Adaptors; or customers can be trained to design and assemble their own.

# FAQs - Will it damage my aircraft/system?

- Unlike HiPot testers, the Ncompass-Voyager will not damage wiring or components because it generates extremely low current levels: less than 1 milliamp maximum.
- Surface mounted components on PCBs have been tested without damage.
- The tester isn't ATEX-cleared but that hasn't stopped us testing several ac types in hangar environments – just set the tester up outside the ATEX zone

# FAQs - It's so sensitive – it will find too many faults that aren't really a problem

- It only finds faults if they are there!  Items with several hundred test points have been tested and found serviceable.
- On a RAF Tornado GR4 testing project, only a handful of the approx 50 test points exhibited faults.  If the Voyager was too sensitive we would have found far more 'events', but that wasn't the case.
- If there is concern about over-sensitivity then the test settings can be adjusted to reduce drive and sensitivity levels and then build them back up until an appropriate level is found.

# FAQs - Is the tester affected by ITAR?

- A product falls under ITAR if it meets one of the product definitions on the US Munitions List [http://www.ecfr.gov/cgi-bin/text-idx?node=pt22.1.121].
- This includes products modified or adapted for military use. The Ncompass-Voyager and its integral Intermittent Fault Detection technology are NOT modified or adapted for military use and have been employed in identical fashion on both civilian and military customer testing projects.
- **This is dual use technology and hence <u>not subject to ITAR.</u>**

# FAQs - What support is available?

- **Training**
  - One day operator training course
  - Plus one day for advanced user training: to set-up test files on NODES and how to design/build IAs
- **Support**
  - One-year warranty as standard
  - Technical Services agreement for problem resolution, Test Programmes, Interface Adaptors,+.
  - Help-desk and extended warranty support available
- **Calibration**
  - Annual calibration and performance check – carried out by us on or off-site.


# Applications where this Technology has Worked

# Used on these……



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# Aerospace Plus….

- Majority of Case Studies are Aerospace, but also applied to:
  - Rail Rolling Stock Components and Door/Brake Loop
  - Military Land Vehicle ISR System Slip-Rings for Quality Testing


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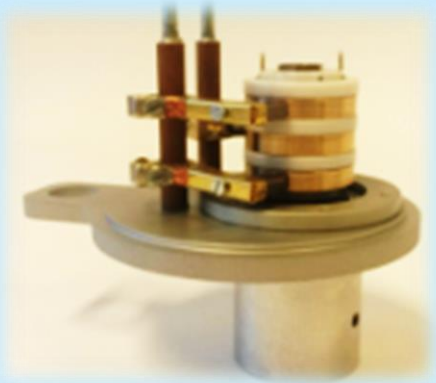

# Slip Rings

Customers are demanding that Slip Ring Manufacturers qualify their products free from intermittent faults; **MIL-PRF-32516** is there to help.


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# MIL-PRF-32516

**23rd March 2015**

## ELECTRONIC TEST EQUIPMENT, INTERMITTENT FAULT DETECTION…….

**1.1 Scope.** This specification covers the minimum **performance**

**requirements** for equipment to detect and isolate **nanosecond,**

**……intermittent faults**, which can occur in any and all of

the……. Line Replaceable Unit (LRU)/Weapon Replaceable Assembly(WRA)

chassis and backplane circuits and their **wire harnesses**.


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# CH-47 Chinook

**Automatic Flight Control System**

- ✓ System wiring tested 75% faster than conventional methods
- ✓ Time-on wing increased significantly for AFCS Computers

**Other Systems**

- ✓ Found inductance problem during safety investigation
- ✓ Quality testing of Circuit Breakers

All of the problems found had been missed by conventional test equipment


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# UH60

**Main Rotor Blade De-Icing Cable Harness**

- High NFF Rate and Mission Abort

✓ Intermittency faults detected and isolated in seconds

✓ Offers pre-installation and periodical wiring health options

All of the problems found had been missed by conventional test equipment


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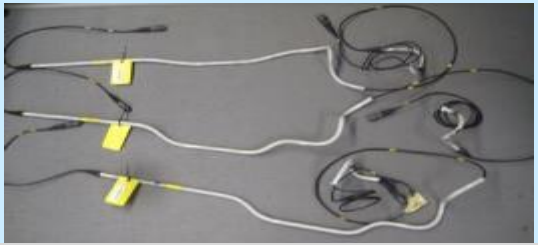
# Eurofighter


**Undercarriage**

- Wiring looms tested whilst exercising them on a mobile vibration system



✓ Intermittency, shorts and high resistance problems found

All of the problems found had been missed by conventional test equipment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# Fast Jet Undercarriage Wiring

## Test Under Vibration

# Cockpit Display: Line Replaceable Units

- 3 x ‘ROGUE’ LRUs.

✓ Intermittent raster card faults detected.

✓ New Raster Cards – assured fault free

✓ Intermittent short found on display connections.

✓ Intermittency on all 3 rear interface assemblies.

**All of the problems found had been missed by conventional test equipment**


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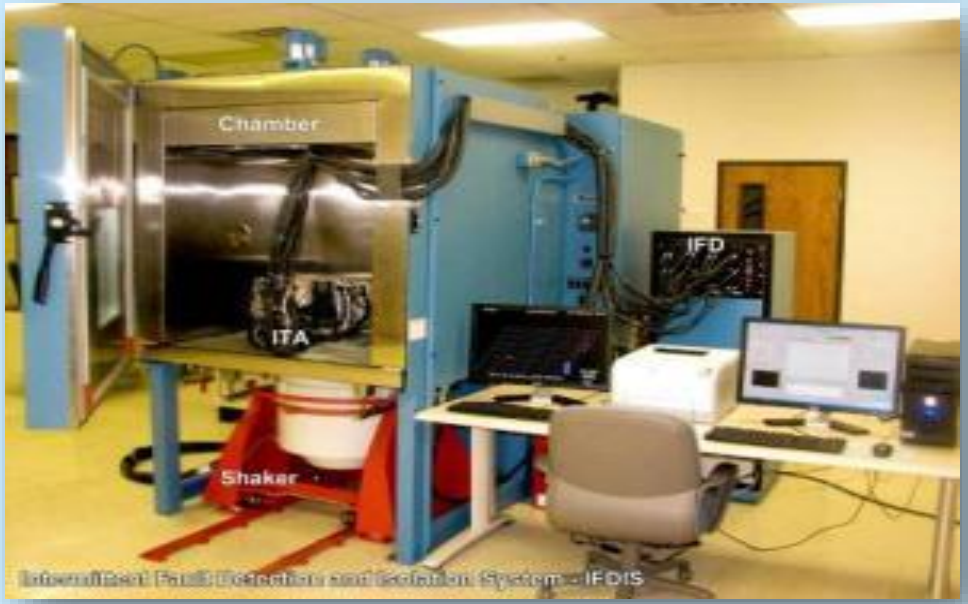


# Other Applications: IFDIS

The Depot Level Tester
Capable of over 8000 lines simultaneously


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# F-16

**ATTACK RADAR**

- 138 “un-repairable” LRUs.
- ✓ Half of all MLPRF tested for intermittent faults were recovered.
- ✓ Over 300% time-on-wing increase (from 290 to 926 flying hours).
- ✓ $62M savings on repaired assets.
- ✓ **RoI : 28.**

All of the problems found had been missed by conventional test equipment


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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




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ISOQAR 0026


**Generator Control Unit**

- GCU **Lead Bad Performer** on F/A-18 Mission Capability list.
- Below advertised MTBF.
- ✓ 21 out of first 27 boxes tested had intermittent fault issues.
- ✓ All repaired, but one failed testing post repair
  - ✓ **New OEM replacement item had intermittent fault**

All of the problems found had been missed by conventional test equipment


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# Growing Group of Satisfied Users of the Technology

## Proven Success

- 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)
- CH-47: AFCS, Wiring Harnesses (EWIS)
- ICBM: Wiring Harnesses (EWIS)
- Tornado GR4: Wiring Harnesses (EWIS)
- Sentinel R1: Wiring Harnesses (EWIS)
- Boeing 757: APU/ECU, TMC LRUs
- Airbus A320: ELAC, BPCU LRUs
- M1-A1 Tank: Wiring (EWIS)
- Automotive
- Light Rail
- Consumer Electronics


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Sustainability funds are limited but so are the tail numbers:

One KC-30A is 14% of the Australian Capability {and 100% of the VIP Fit}


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**Air Force Values:**

Respect

Excellence

Agility

Dedication

Integrity

Teamwork

Plan Jericho Cover


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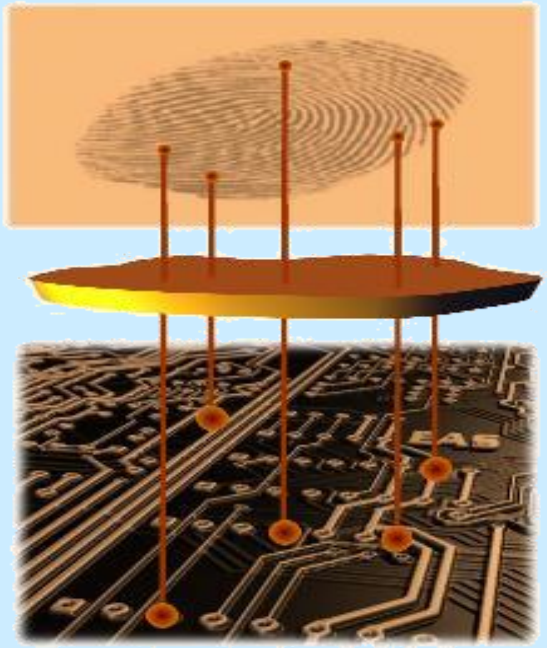
# Prognostic FingerPrint© Technology




Vector Indicators
Matrix of Voltage,
Current, Power,
Time, Phase ,
Frequency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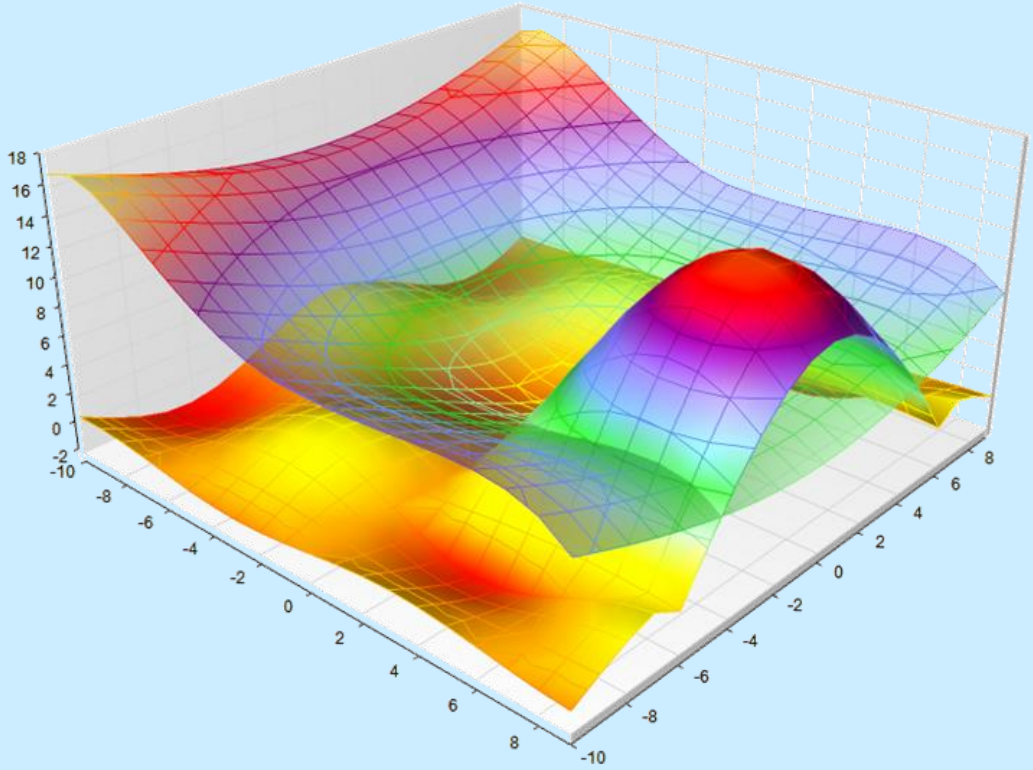
ISOQAR
UKAS

**Overlay**
**“Actual” on a “Gold” to**
**Identify the ‘Differences’**





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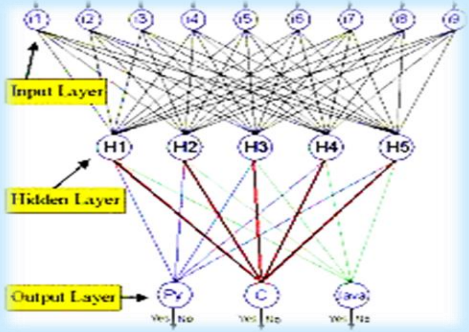
# Using Neural-Network Test Technology for Avionic Systems Maintenance

***From This***




***To***

***This***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ISOQAR
UKAS MANAGEMENT SYSTEMS
0026


- Whole-of-Life qualification of cables, connectors and chassis.
- Finds faults conventional ATE misses: ( clue….. intermittence).
- Tests 75% faster than ATE.
- Repairs remain 3 x longer ‘on-wing’
- $100m savings by repairing not replacing.
- RoI within 6mths on a $7m program.


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