

Solving the Mystery of the Disappearing Symptom

and Why it Benefits the Product Life-Cycle



A Critical Motivating Factor in What We Do.....

WHICH PARTS DO **YOU** WANT TO PAY
ATTENTION TO IN THE NEXT 15 MINUTES?





WHICH PARTS DO **YOU** WANT TO PAY
ATTENTION TO IN THE NEXT 15 MINUTES?

Logic or
Magic Dust?





WHICH PARTS DO **YOU** WANT TO PAY
ATTENTION TO IN THE NEXT 15 MINUTES?



**The
disappearing
symptom;**

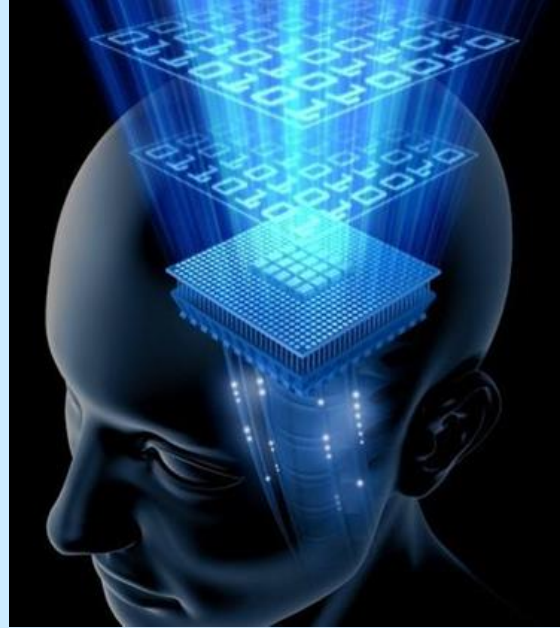
By the time the
technician gets
access.....
the fault is gone





Technological

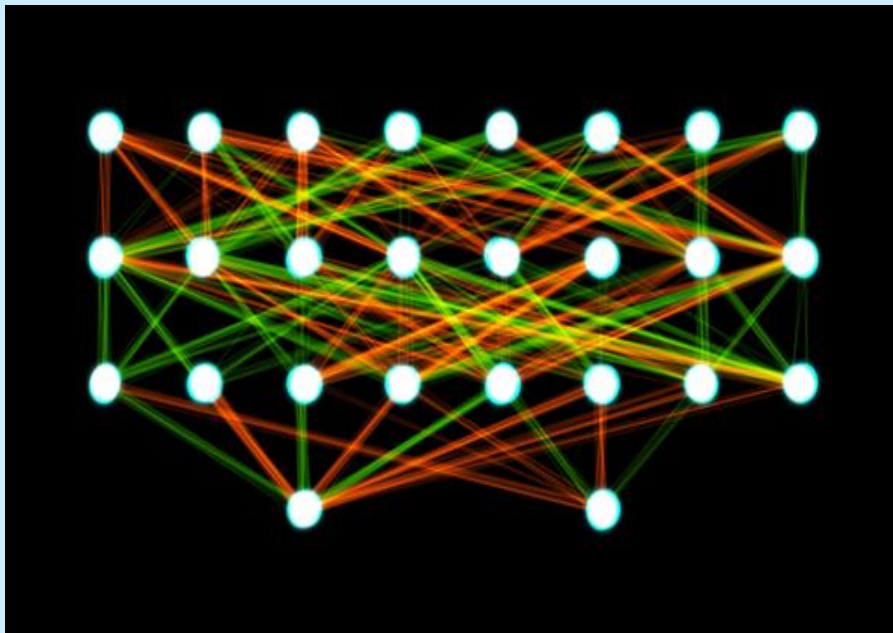
WHICH PARTS DO **YOU** WANT TO PAY ATTENTION TO IN THE NEXT 15 MINUTES?

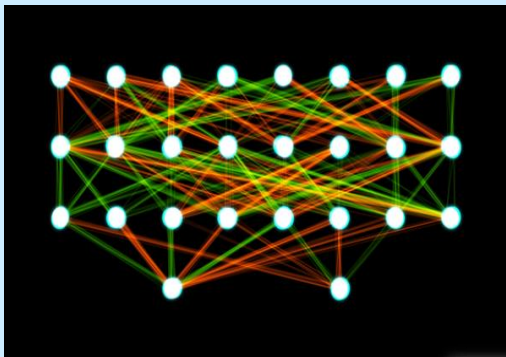




A Neural Network?

WHICH PARTS DO **YOU** WANT TO PAY
ATTENTION TO IN THE NEXT 15 MINUTES?

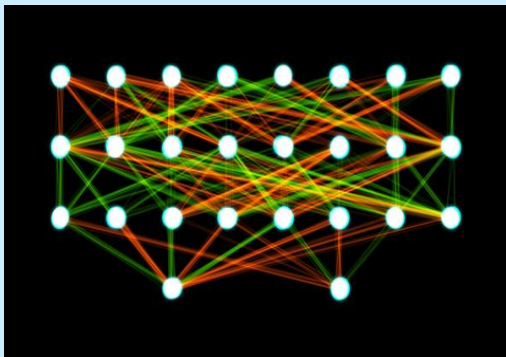




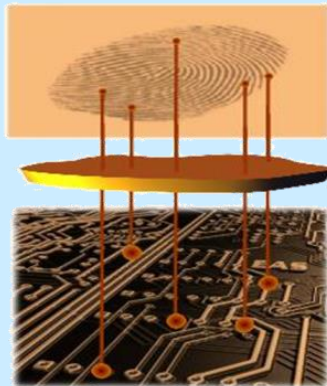
WHICH PARTS DO **YOU** WANT TO PAY ATTENTION TO IN THE NEXT 15 MINUTES?

I want to know who this has helped.....?





WHICH PARTS DO **YOU** WANT TO PAY ATTENTION TO IN THE NEXT 15 MINUTES?



Vector Map

Processing Layer

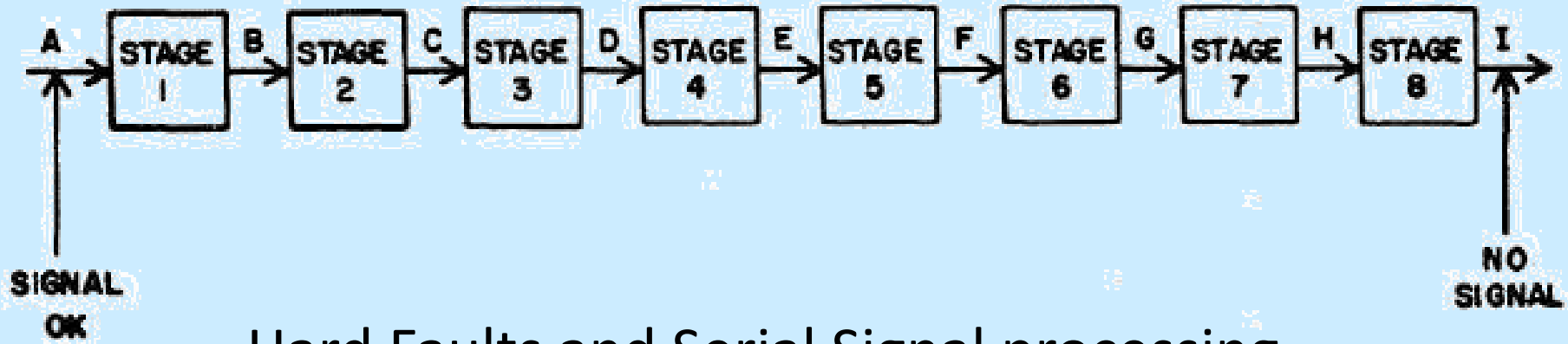
Data Acquisition

And for the
Future.....
FingerPrinting©



AA&S 2017
(Australia)

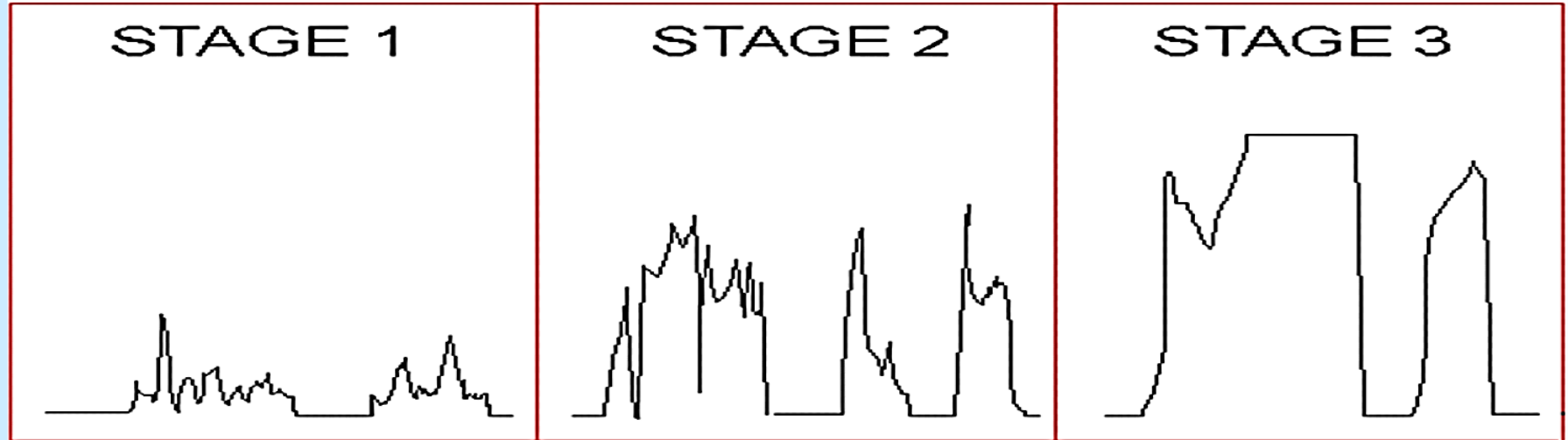




Hard Faults and Serial Signal processing

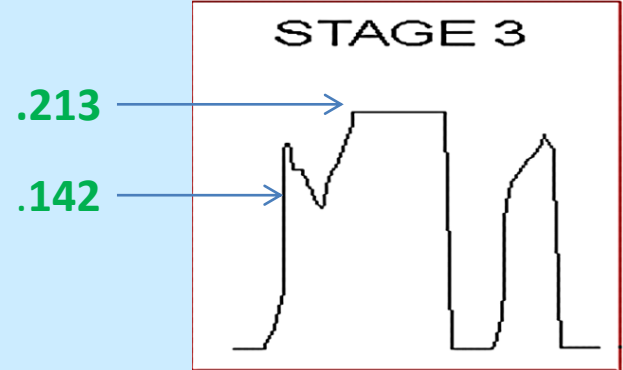
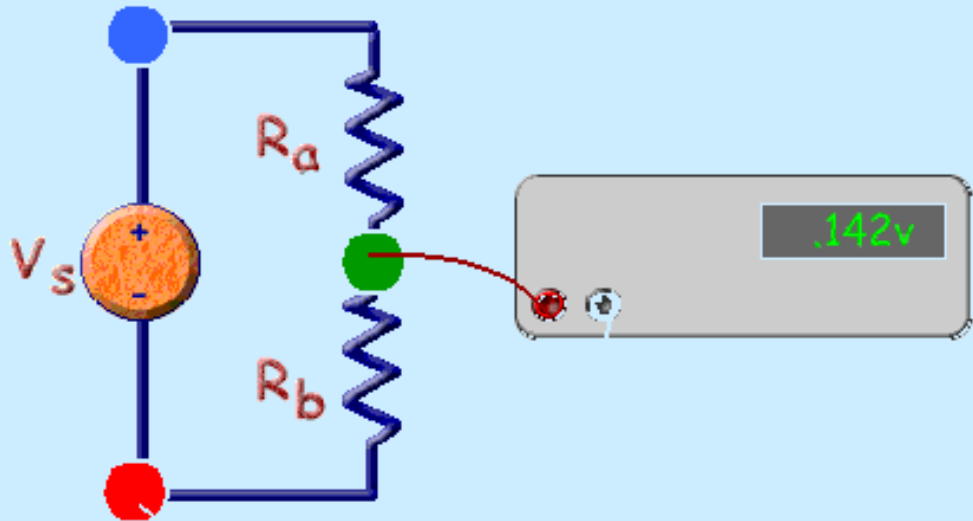


Then this comes along.....

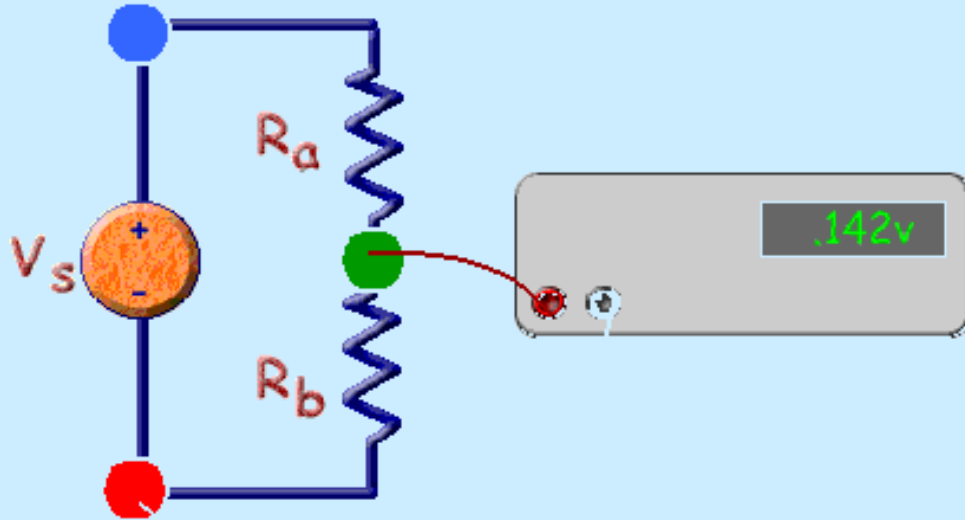


Conventional Test Equipment **AVERAGES** values
And looks like.....

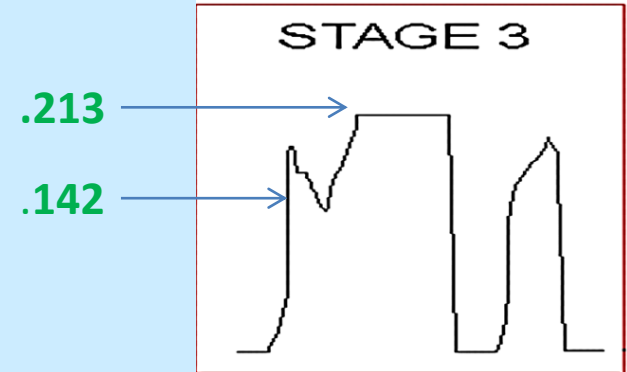
[How is done Today?]



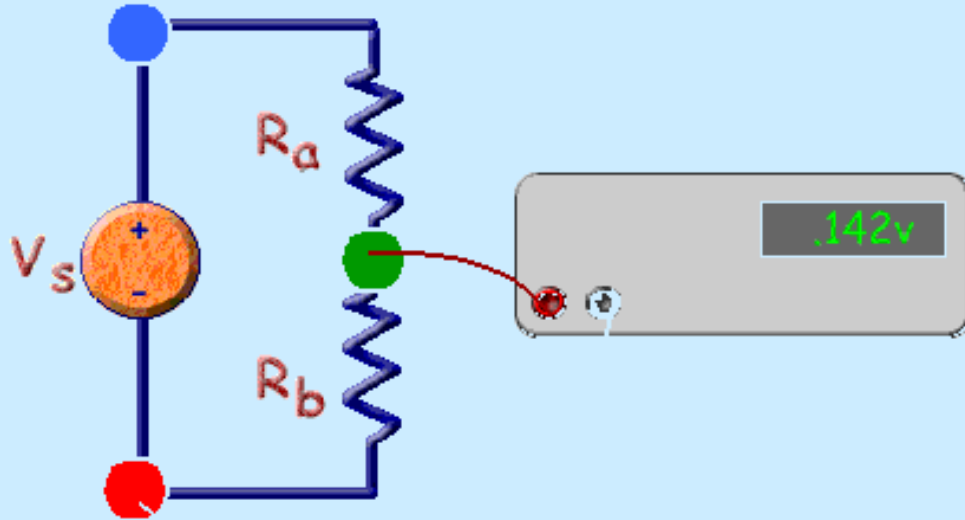
Conventional Test Equipment **AVERAGES** values
And looks like.....



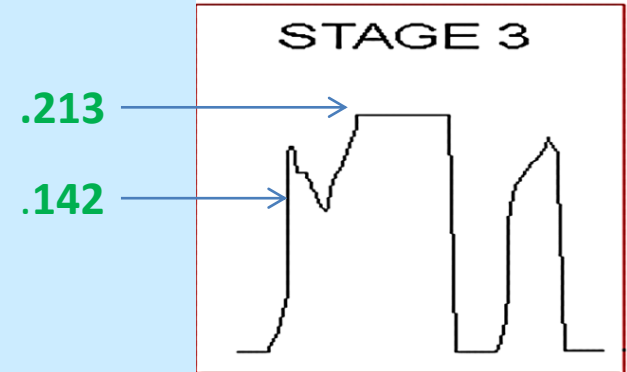
What DO I need to measure
it accurately?.....



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



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



Something that captures the glitch



How big is this Avionic “Problem”.....?

No-one has brought it to my attention?

Of the **US\$80b** spent on repairs and maintenance,
The US Department of Defence estimates that
Intermittent Faults cost US\$2b to 10b.



How Big is the “intermittent” Part of the Larger Maintenance Problem.....?

Big enough to galvanise the effort to raise a
Military Performance Specification:MIL-PRF-32516

Answer: For the US DoD, \$2b in a \$80b support bill



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**.



Where to Focus the Technology?

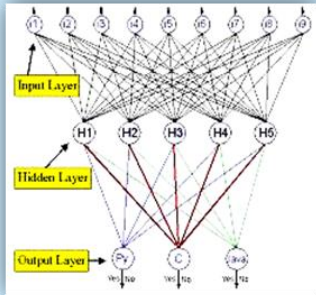
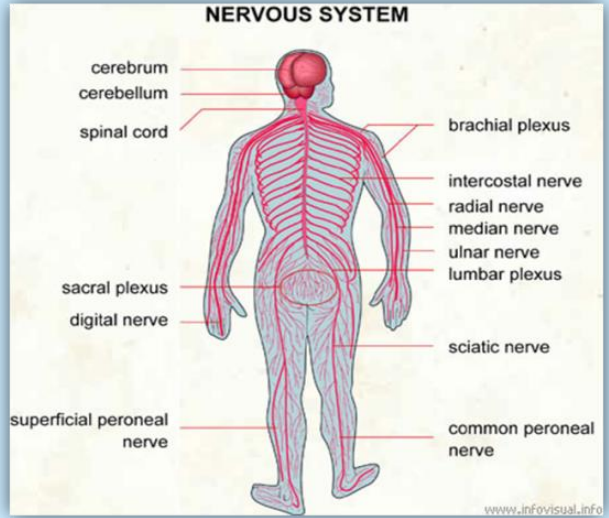
DSAS_ID	Reference_Dat	Full_IdentRef	KeyRunHrs	InputSentence	MRC_No	Symptom	inal_Part_Descri	viewed_Part	SerNos	Activity	alDescriptionO	Total_Hours_Worked
1380	01-Aug-11	ABC014	5190	-	272	APU START ACCUMULATOR GUAGE FROZEN	GAGE,PRESSU		R(?) -(?) +(?)			0.08
1381	01-Aug-11	ABC014	5190	-	273	POWER STEERING GUAGE FROZEN	GAGE,PRESSU		R(?) -(?) +(?)			0.08
1382	01-Aug-11	ABC015	6135	-	7410	(REVIEW OF LIM 69/3) UPPER I/R STROBE U/S	ANTI-		R(?) -(?) +(?)			0.17
1383	01-Aug-11	ABC015	6135	-	7432	REVIEW OF ADF 103/5 (REAR AOBT UNIT TO BE	ACTIVE		R(3146) -			3.67
1384	02-Aug-11	ABC014	5190	-	278	FWD HEAD LEAKING	SEAL_PLAIN		R(?) -(?) +(?)			0.08
1385	02-Aug-11	ABC014	5190	-	279	HF DOES NOT TRANSMIT	POWER AMP		R(202) -(202)			0.08
1386	02-Aug-11	ABC024	6272	-	3580	FWD HEAD LOWER INNER VHP SEAL SPLIT	SEAL_PLAIN		R(?) -(?) +(?)			4.33
1387	03-Aug-11	ABC024	6272	Fix	1966	CORRUPTED TEXT AT TOP EDGE OF DISPLAY	Display	NV-15927-55-	R(?) -(?) +(?)	Repair		0.75
1388	03-Aug-11	ABC005	5672	-	3743	PILOT JETTISONABLE DOOR PAINT SURFACE	DOOR,JETTISO		R(NONE) -(?)			7.75
1389	03-Aug-11	ABC005	5672	-	3744	COCKPIT SIDE FORMER, RIGHT HAND SIDE,	FORMER		R(NONE) -(?)			19
1390	03-Aug-11	ABC005	5672	-	3745	L/H UPPER FWD FILLET PANEL; FOUND DAMAGED	SKIN,AIRCRAFT		R(?) -(?) +(?)			3.33
1391	03-Aug-11	ABC005	5672	-	3750	CVFDR Channel Yaw Pedal - No Signal Ref Form 95;	CPT-		R(60401) -	Repair		14
1392	04-Aug-11	ABC014	5190	-	248	POWER STEERING - SWIVEL LOCK	ACCUMULATO		R(?) -(?) +(?)			0.08
1393	04-Aug-11	ABC014	5190	-	283	APU START ACCUMULATOR FROZEN	ACCUMULATO		R(?) -(?) +(?)			0.08
1394	04-Aug-11	ABC005	5672	-	3777	CO-PILOTS CCP BUTTONS STICKING DUE TO	CONTROL,		R(C79901) -			1.83
1395	04-Aug-11	ABC005	5672	-	3778	VOR ANTI-VIB MOUNTS U/S	MOUNT,RESILI		R(?) -(?) +(?)			14.33
1396	04-Aug-11	ABC015	6135	-	7467	HUMS ACCELEROMETER No 20 TRANSMSSION	HUMS		R(?) -(?) +(?)			1.5
1397	04-Aug-11	ABC015	6135	-	7471	NRC DEBONDED AT TIP LEADING EDGE ON MRB A	FORWARD		R(A-1-118) -			0.17
2064	04-Aug-11	ABC024	6275	Fix	3355	MESSAGE GARBLED TOP EDGE	Display	NV-15927-55-	R(NONE) -(?)	Repair	display	3.5
1398	05-Aug-11	ABC024	6272	-	3596	APU ON CAPTION FAILING TO ILLUMINATE	ELECTRONIC		R(2692) -			3.75
1399	05-Aug-11	ABC015	6135	-	7477	RCDU CB CAP REMOVED (NOT LOOSE ARTICLE)	CIRCUIT		R(?) -(?) +(?)			0.83
1400	05-Aug-11	ABC015	6135	-	7478	AFT (YLON LOWER L/H INSPECTION FLIPPER	LEAD,ELECTRI		R(?) -(?) +(?)			2.25
2065	06-Aug-11	ABC024	6277	Fix	3365	CANNOT READ TOP EDGE TEXT	Display	NV-15927-55-	R(NONE) -(?)	Repair	display	4.2
1401	08-Aug-11	ABC024	6272	-	3597	MAIN BATTERY TO BE REPLACED	BATTERY		R(10302418) -			1
2066	08-Aug-11	ABC024	6281	Fix	3378	LETTERS GARBLED DISPLAY TOP	Display	NV-15927-55-	R(NONE) -(?)	Repair	display	5.1
1402	09-Aug-11	ABC014	5193	-	312	ON SHUTDOWN No 2 ECU , F1 AND F3 FADEC	ENGINE		R(F171) -			0.08
1402	09-Aug-11	ABC014	5193	-	312	ON SHUTDOWN No 2 ECU , F1 AND F3 FADEC	ENGINE		R(F171) -			0.08



Narrow the Search.....

DSAS_ID	Reference	Full_Ident	KeyRunHr	InputSente	MRC_No	Symptom	inal_Part_Des	viewed_Pai	SerNos	Activity	alDescription	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





What is a NEURAL NETWORK?

[What's new, Why will it be Better?]



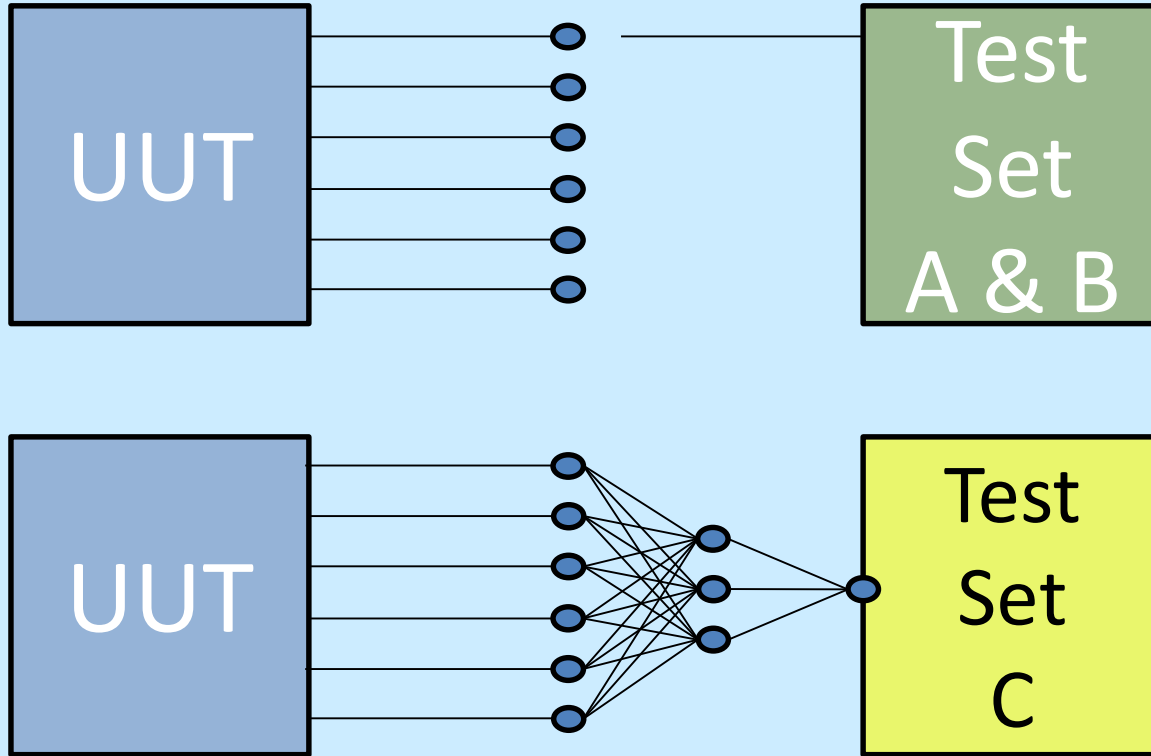
How Will this Technology Help Me?.....aka, How Will it Save Me.....

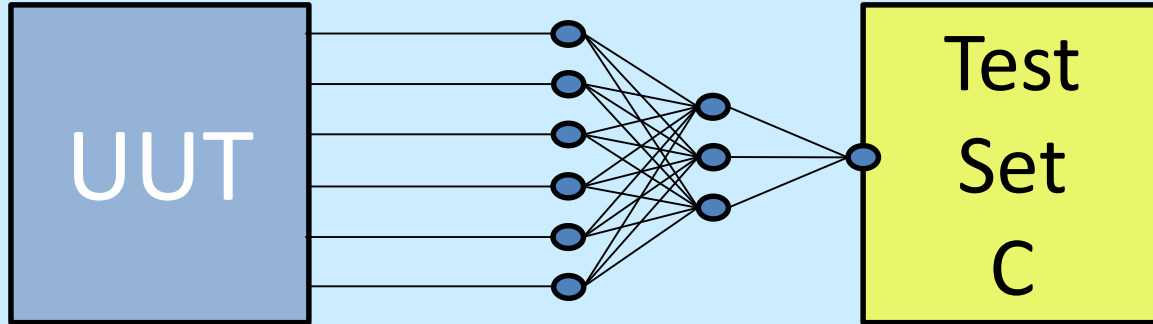
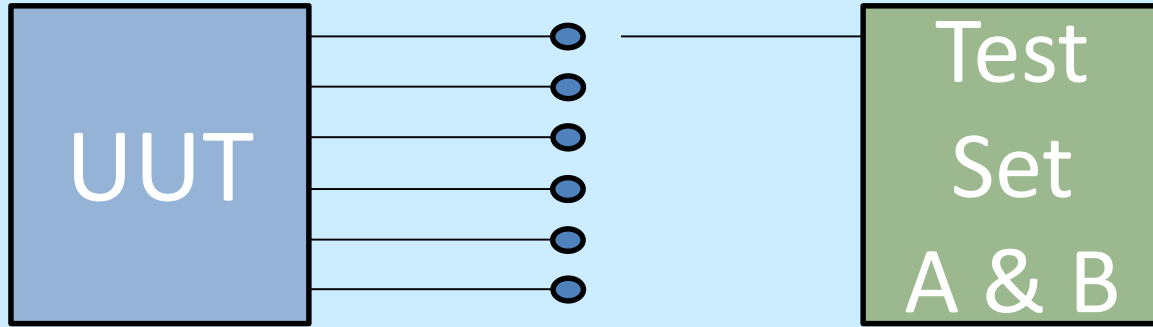


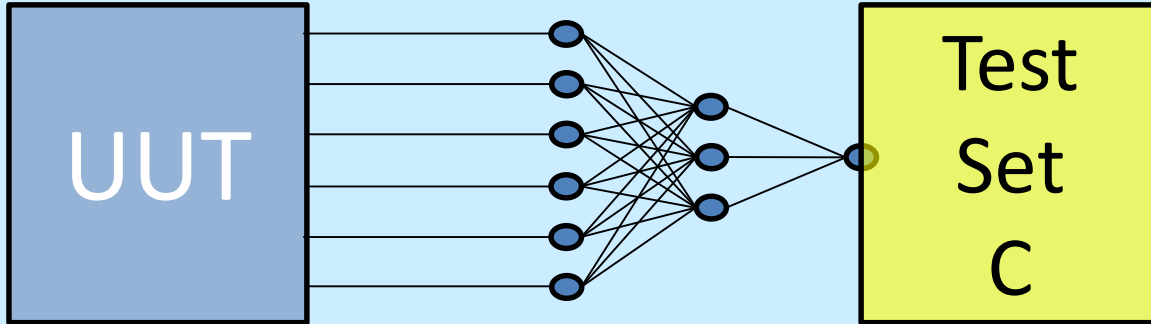
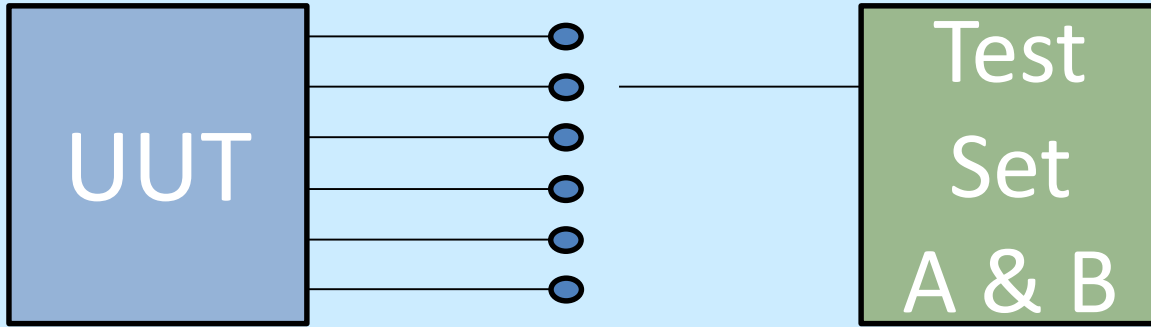
By finding things others can't find

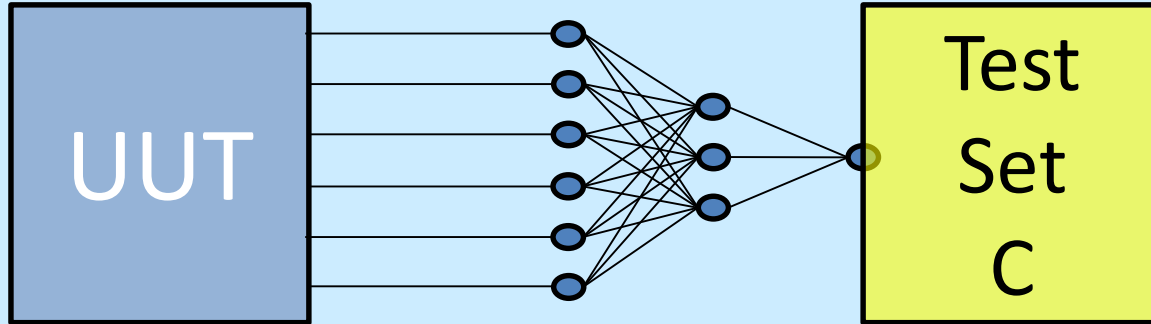
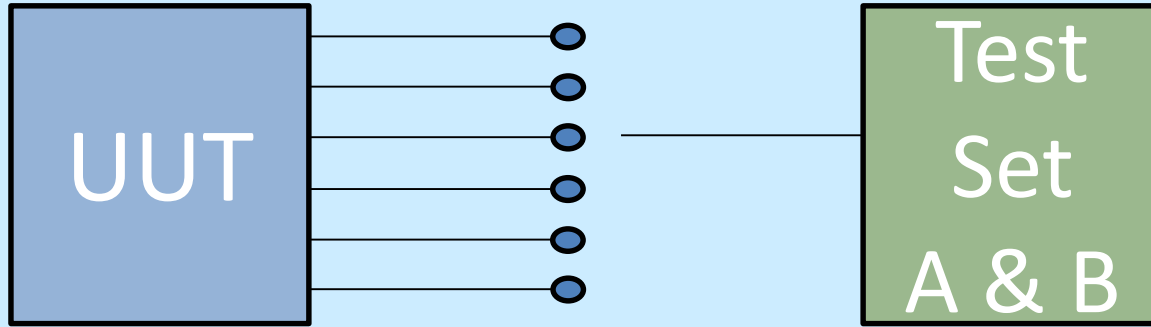


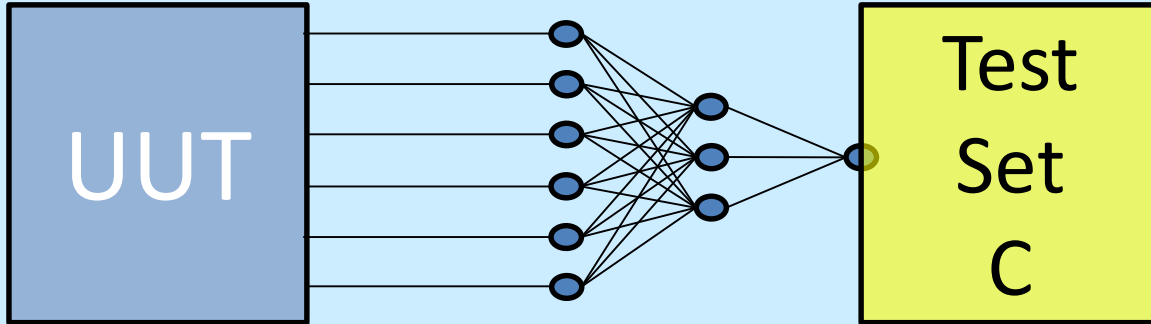
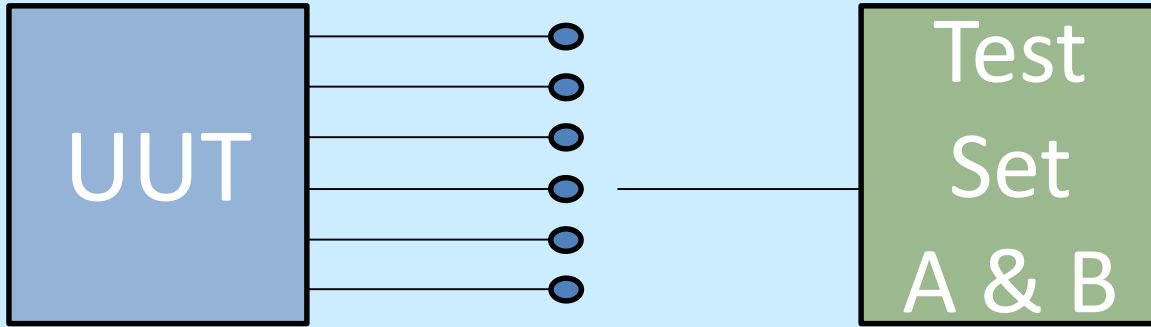
Detection Simulation: Probability of Detection

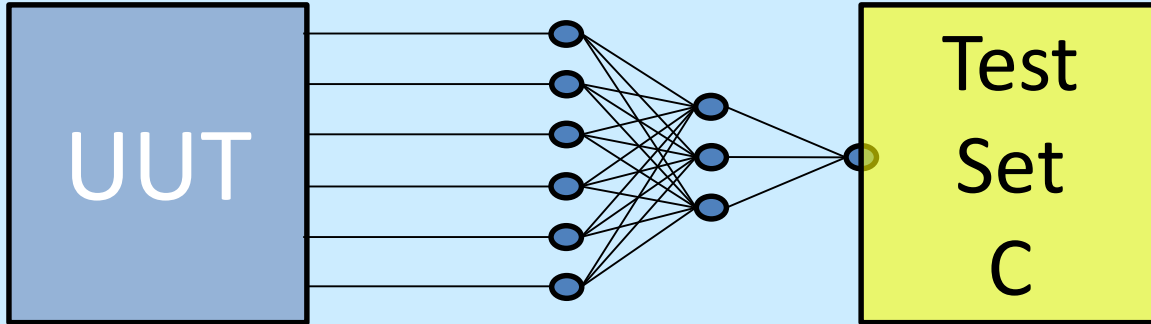
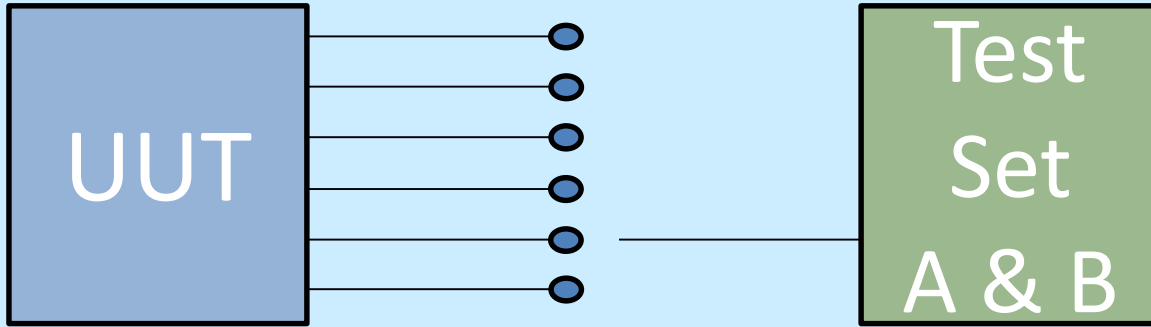


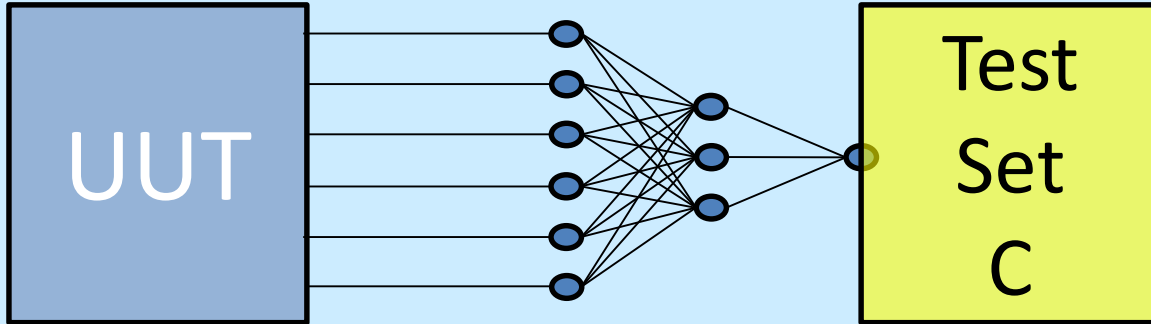
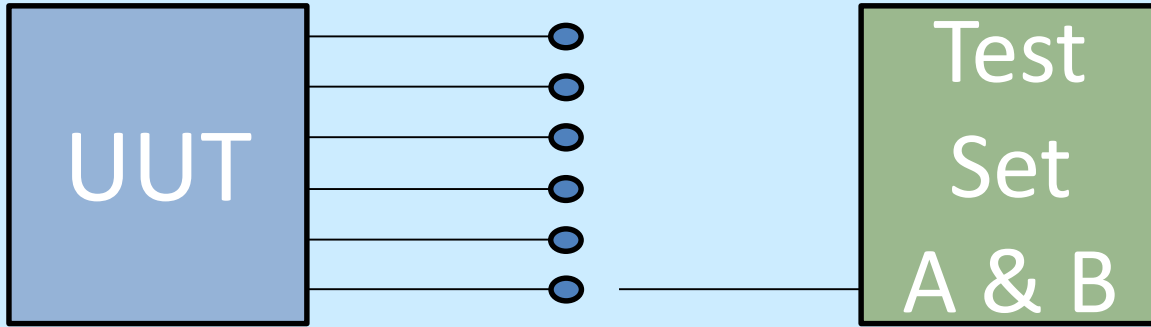


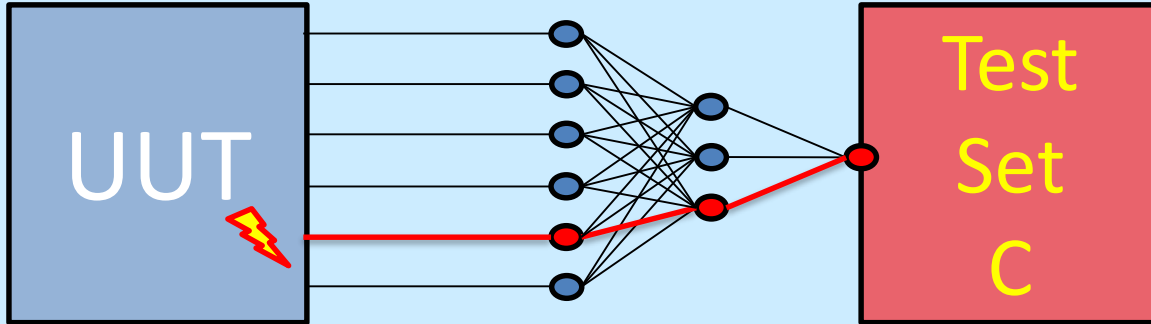
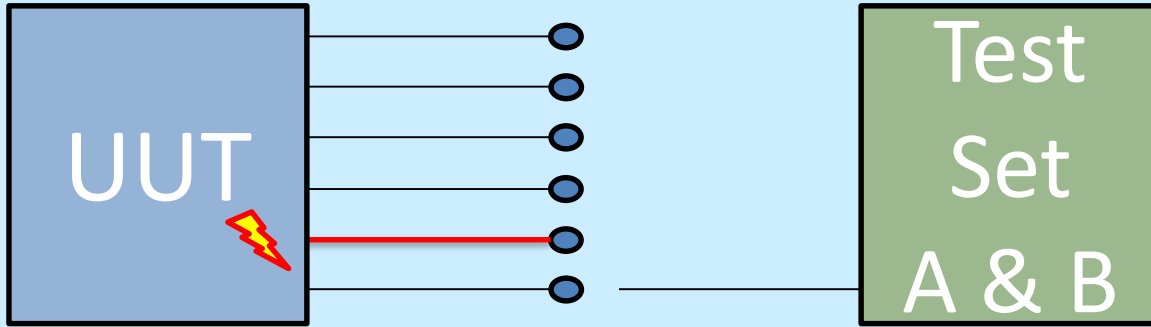


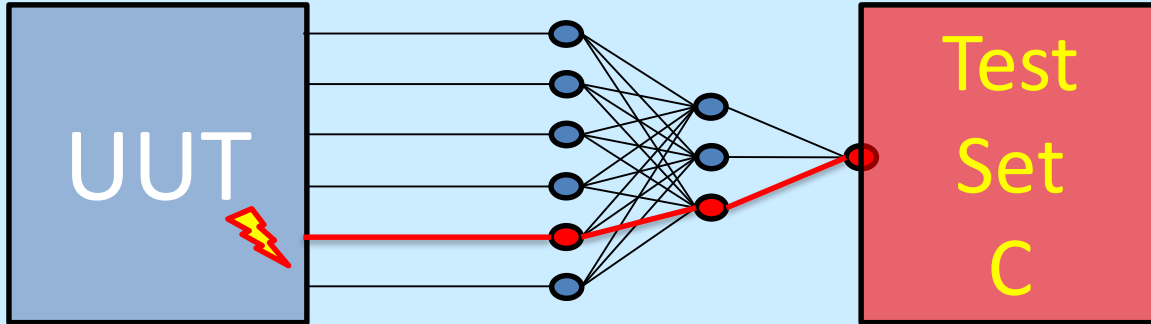
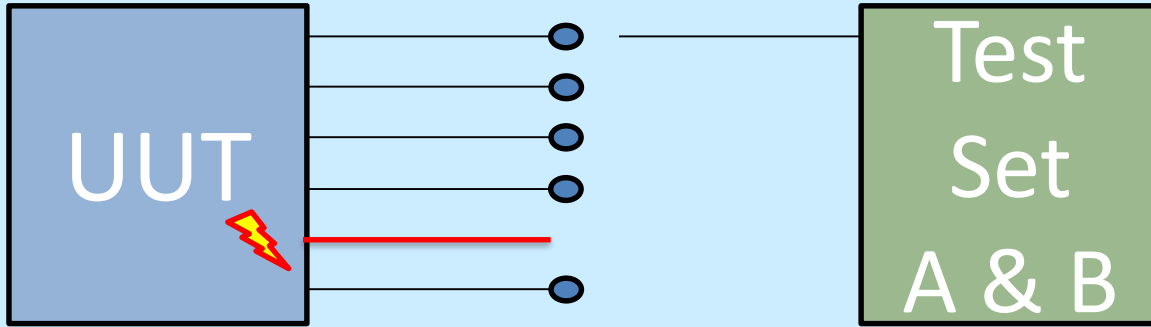


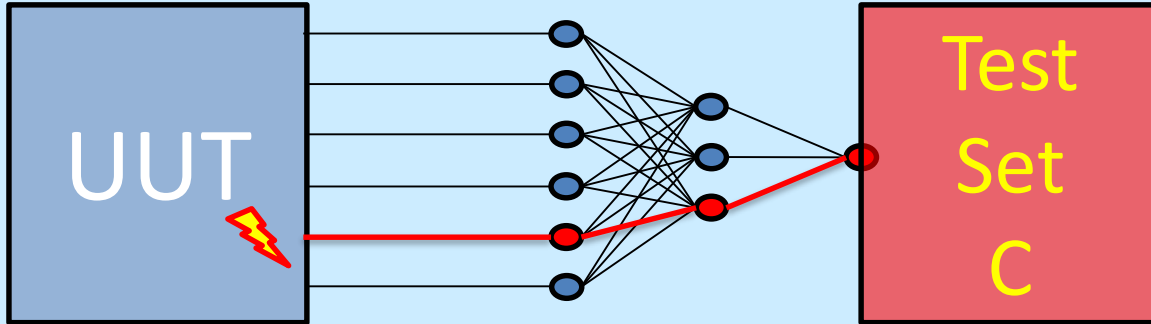
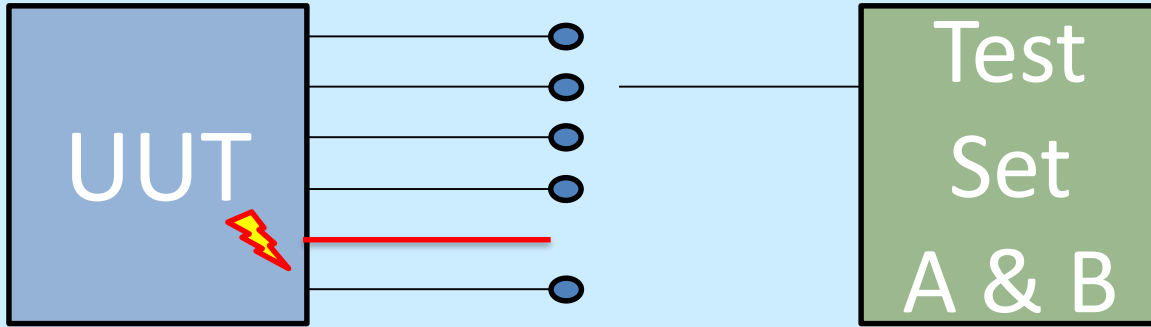


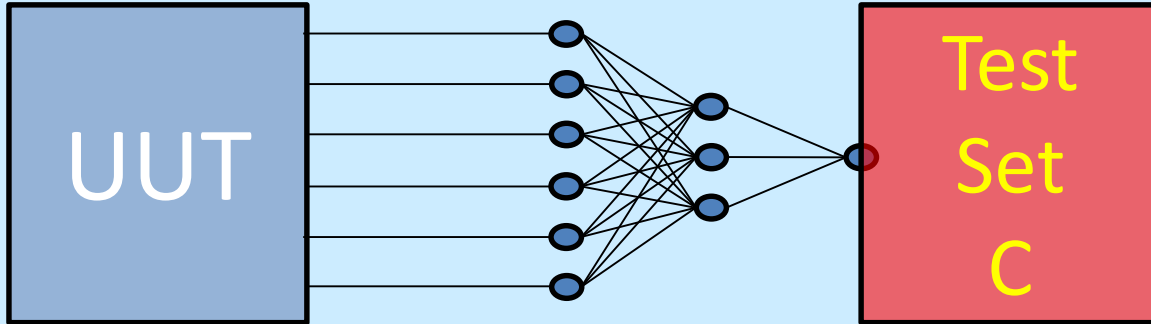
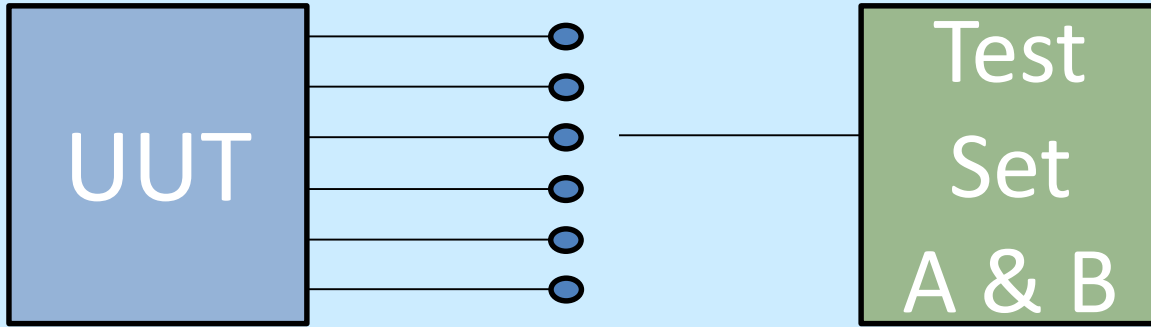


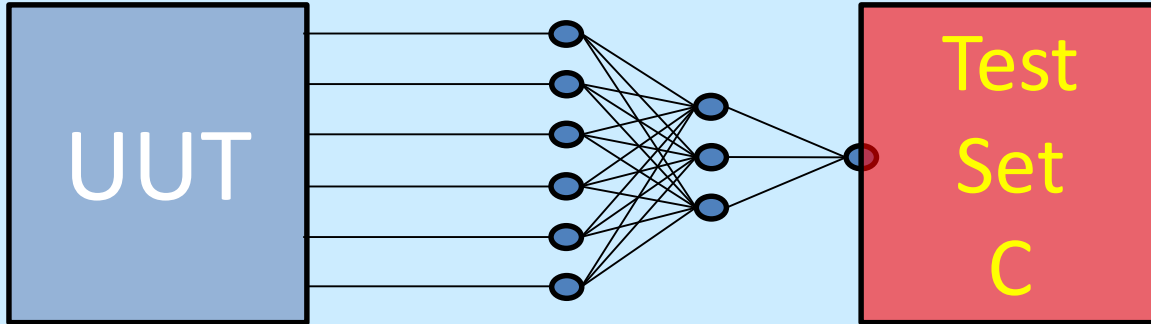
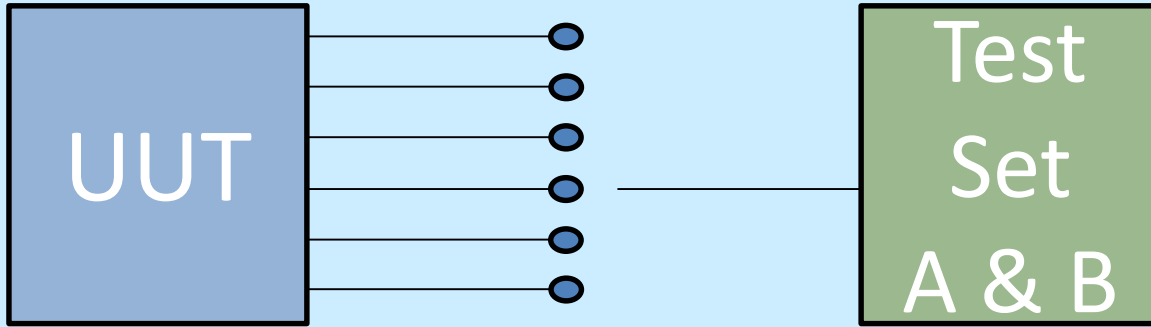


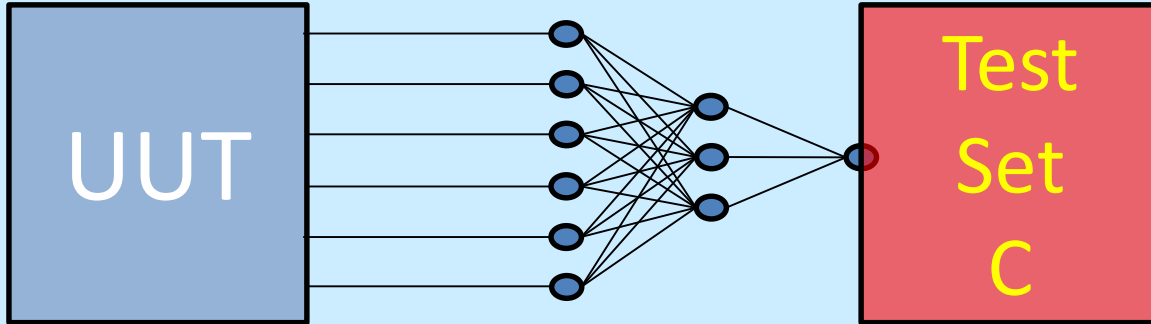
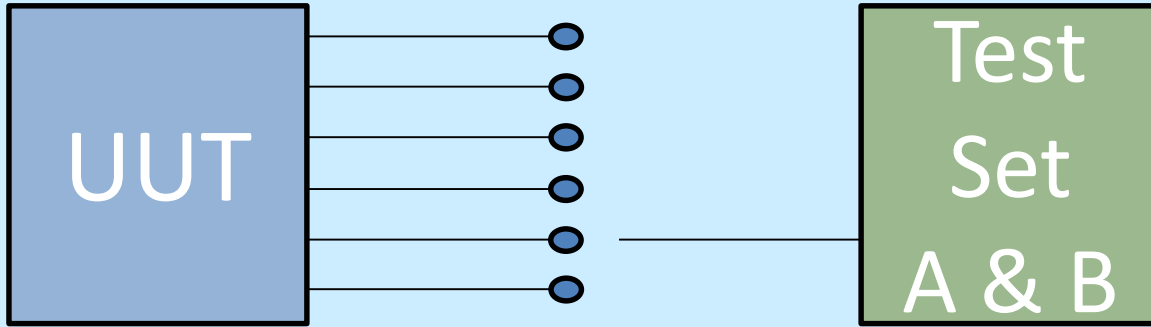


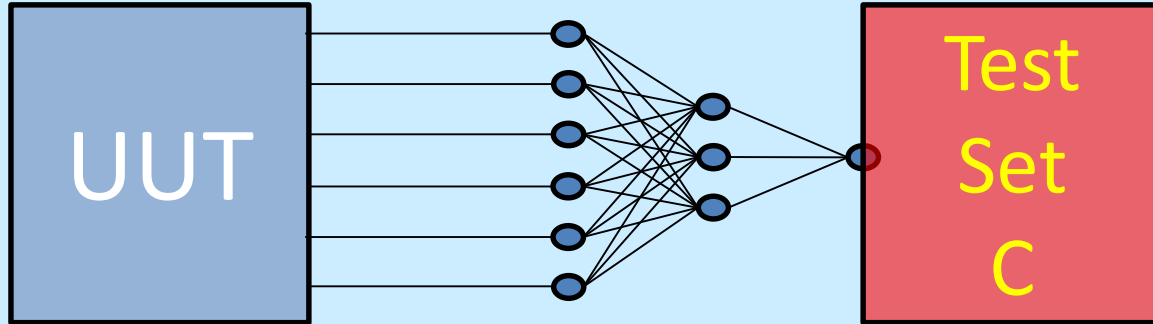
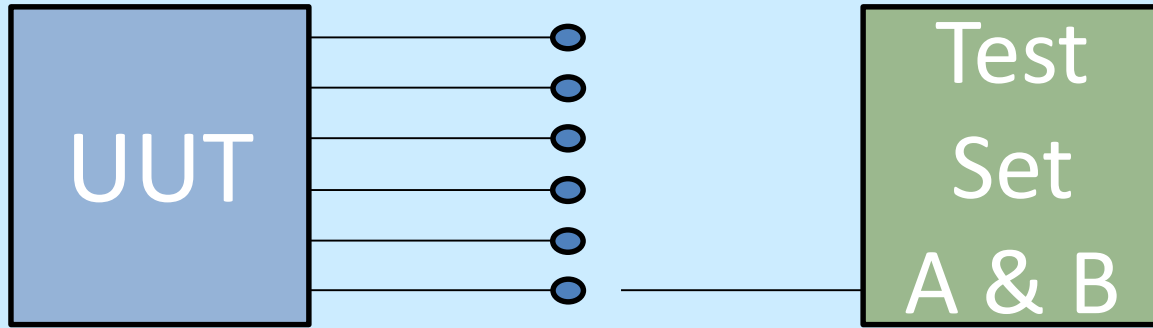








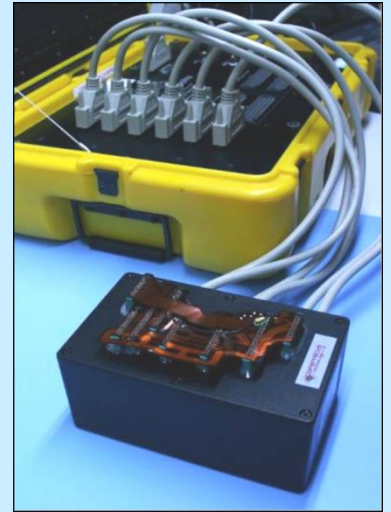




Got the problem, seen one solution, How is My Organisation Managing It?.....

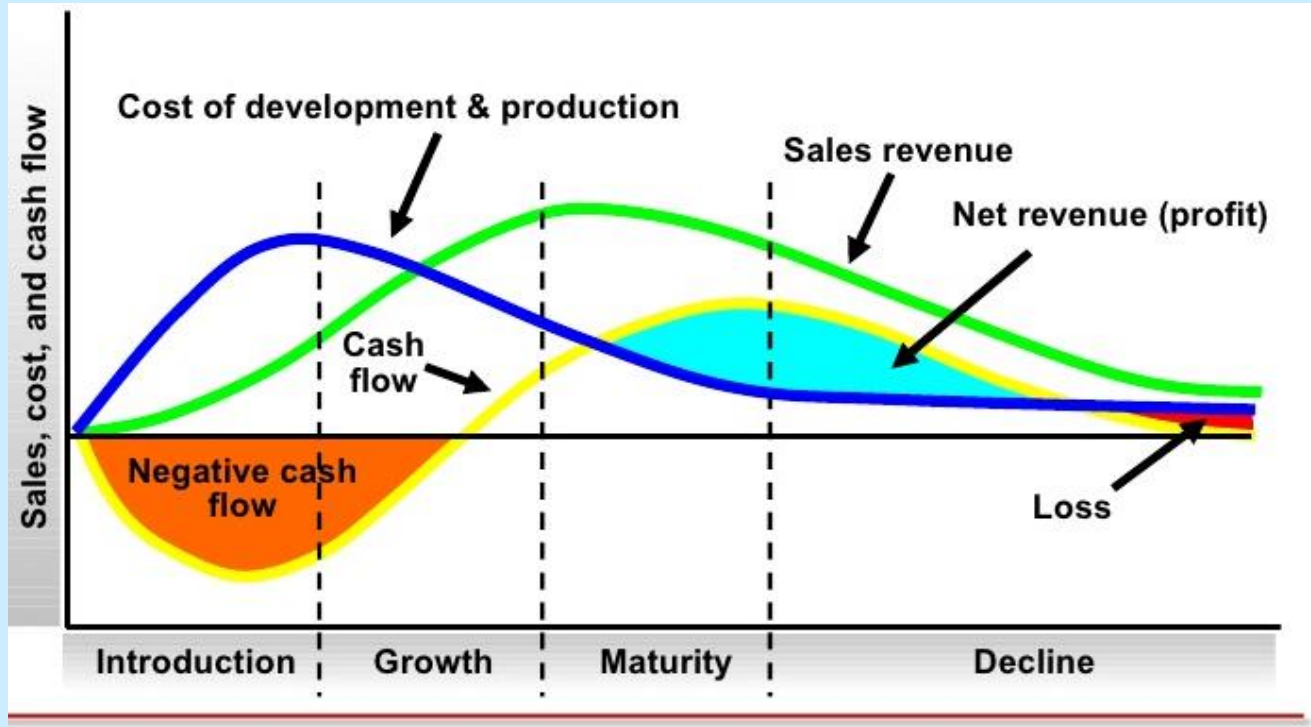
n

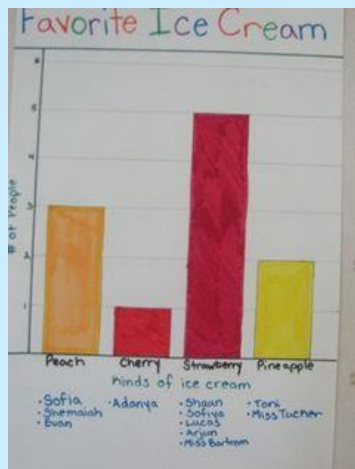
or



Smart technology will help
with **FAULT FINDING** and
prevent gaping **HOLES**...
but what about earlier in
the fault chain.... say at
manufacture?







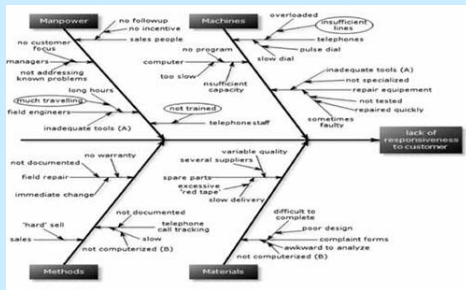
Collection of Data related to the problem

- The teacher should suggest the available resources like books, journals, periodicals, et with respect to the problem given to the students. Also he must encourage the students to collect data from different sources.



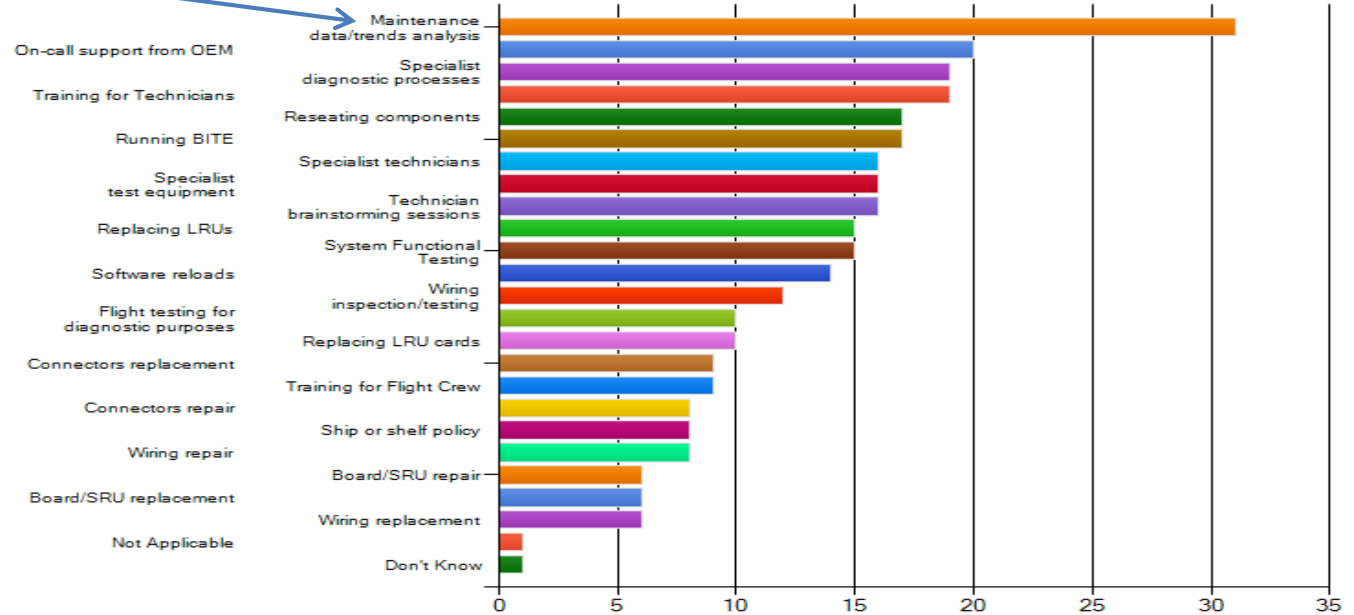
“The FIRST Stage of the assessment was to collect detailed information about the inspection process.”

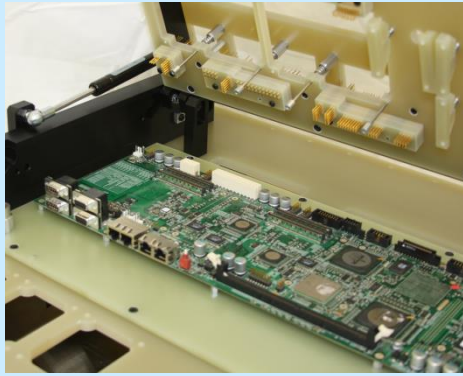
Occupational Ergonomics: Principles of Work Design Waldemar Karwowski, William S. Marras



Maintenance data/trends analysis

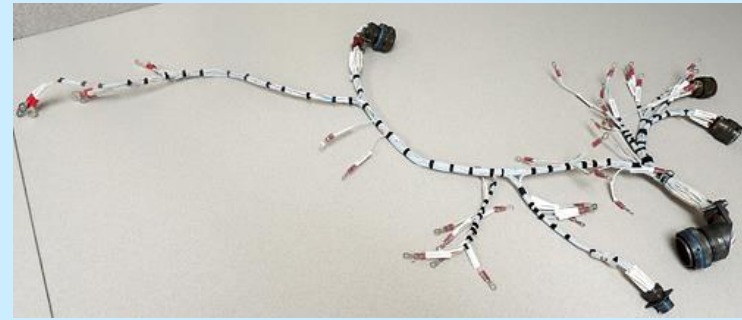
What are the main approaches that your organisation uses already to reduce NFF occurrences? Choose all that apply.





For boards

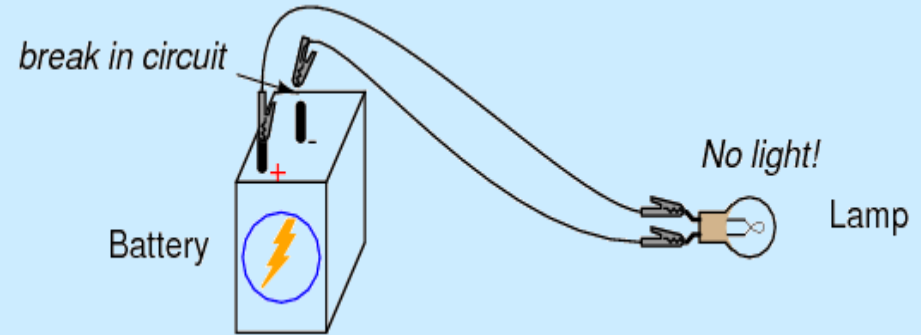
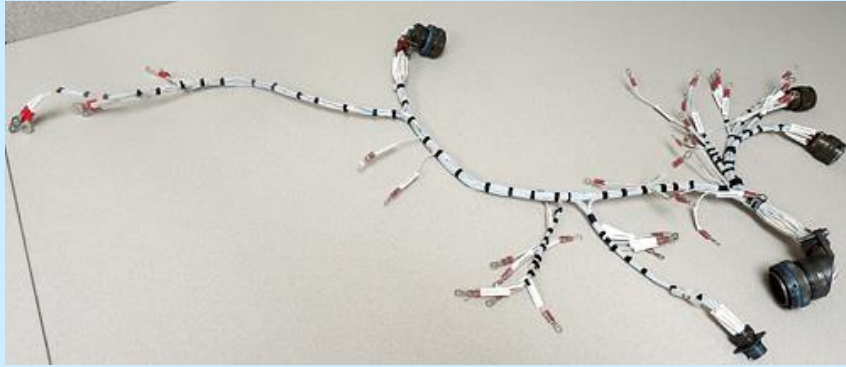
For modules



Before and after installation is there any discreet testing **or** do we take it for granted?

?





Environmental Degradation



Reliability, Availability and Maintainability

Support to the CH-47D Chinook in the Middle East Area of Operations
CAPT Paul Bellas



Question

But is this how they REALLY are?

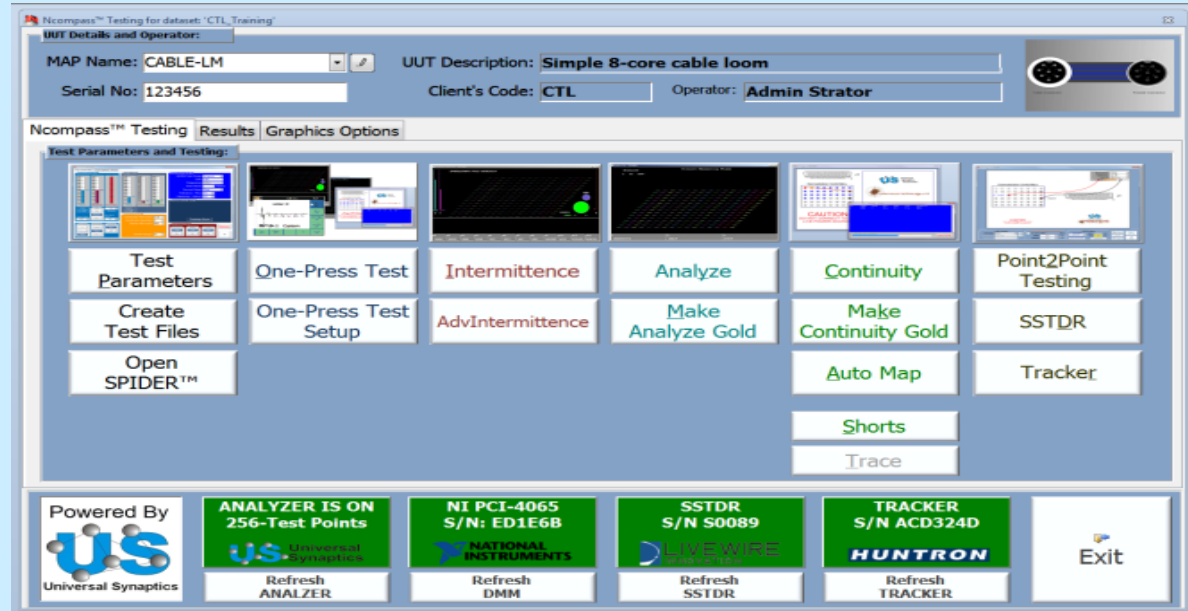


Is this how YOU See the
Cables and connectors
in your system?





Test Functions



Whole-of-life In-Service Fault Finding and Trend Analysis

Fast detection of faults in:

- Wiring
- EWIS components (CBs, relays)
- LRU external and chassis interconnects
- Ribbon-cables
- PCB connections

Production Quality Testing & trending:

- New-build wiring looms and chassis
- Validate new and modified wiring installations.



Uses



Applications where this Technology has Worked



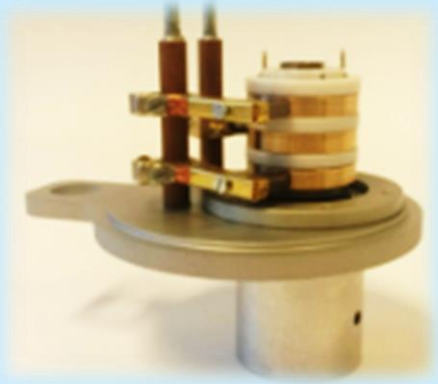
Used on these.....



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





Slip Rings

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





EWIS

C-130J

- System had major NFF issues.
- ✓ Successfully detected and isolated intermittent fault on system wiring



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





CH-47 Chinook

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

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](#)



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



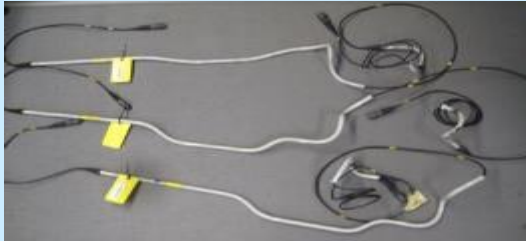
All of the problems found had been missed by conventional test equipment



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





Fast Jet Undercarriage Wiring

Test Under Vibration



Intelligence, Surveillance, Reconnaissance

Avionics EWIS Integrity Testing

- Repeat mission system failure.
- 500+ hours of fault-finding over 9 mths
- ✓ Testing identified root cause of intermittent faults within 2 days.
- ✓ Identified HOW intermittent failure mechanisms developed.
- ✓ Introduction of preventive procedures.

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



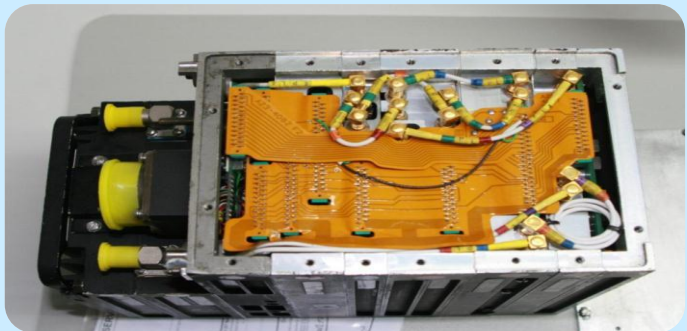
Airline Display LRU

- 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





Helicopter Radio Backplane

45% NFF across 3 platforms.

Back-plane was the main intermittency risk.

- 57% failed intermittency & continuity tests.
- 75% of the failed items had passed ATE testing.



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





Other Applications: IFDIS

The Depot Level Tester
Capable of over 8000
lines simultaneously



F-16



ATTACK RADAR

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

*[What are the Payoffs?
What are the risks?]*

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





Programmable Signal Processor– RADAR

- 54% NFF Rate.
- USAF Depot and OEM unable to improve performance.
- ✓ Jan to Jun 2015, 23 out of 24 units tested were fixed.
- ✓ Within 6 months programme had paid for itself plus 15%.
- ✓ Expected ROI: 500% within 2 years

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





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



AA&S 2017
(Australia)

© 2017 Copernicus Technology Ltd. All Rights Reserved.
CopernicusTechnology.com





Generator Control Unit

- GCU **Lead Bad Performer** on F/A-18 Mission Capability list.
- Below advertised MTBF.
- ✓ 21 out of first 27 GCUs 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



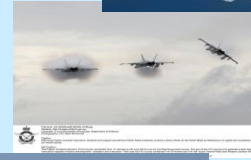
Growing Group of Satisfied Users of the Technology

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



Is your Capability being Judged by Dollars or by Availability?



Perhaps a Capability GAUGE Paints a Different Picture





The BoneYard....

One Tail Number
Unserviceable
can be Tolerated





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



Measured by
CAPABILITY..... LOSS is
a Different Equation



Measured by CAPABILITY..... LOSS is a Different Equation

TEAMWORK

What if you Add ALL
of the Capability Tail
Numbers on the One
Base that could
benefit from a
Neural Network
Capability?



Measured by
**CAPABILITY..... LOSS is
a Different Equation**

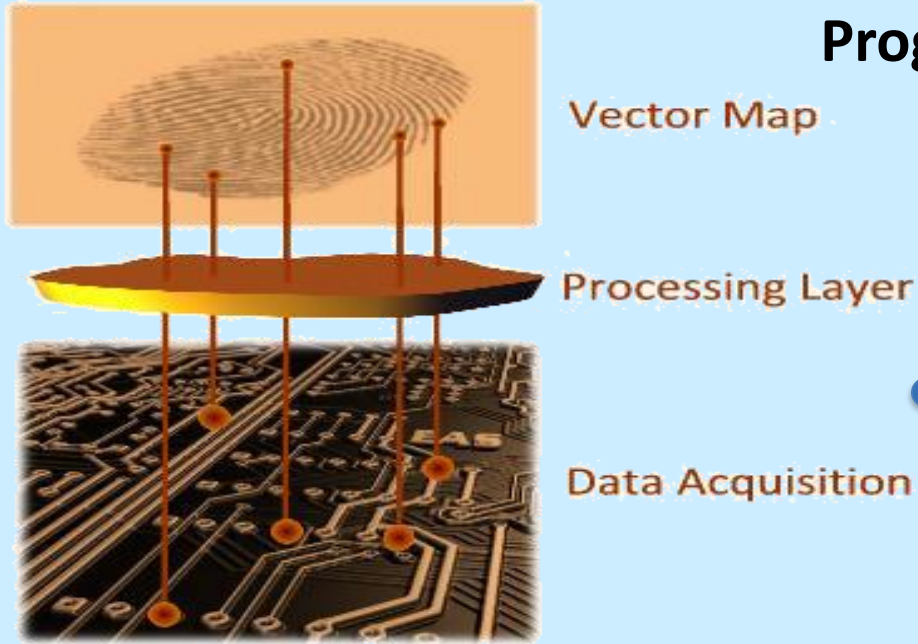
Air Force Values:
Respect
Excellence
Agility
Dedication
Integrity
Teamwork

Plan Jericho Cover

*[How much will it cost?
How long will it take?]*



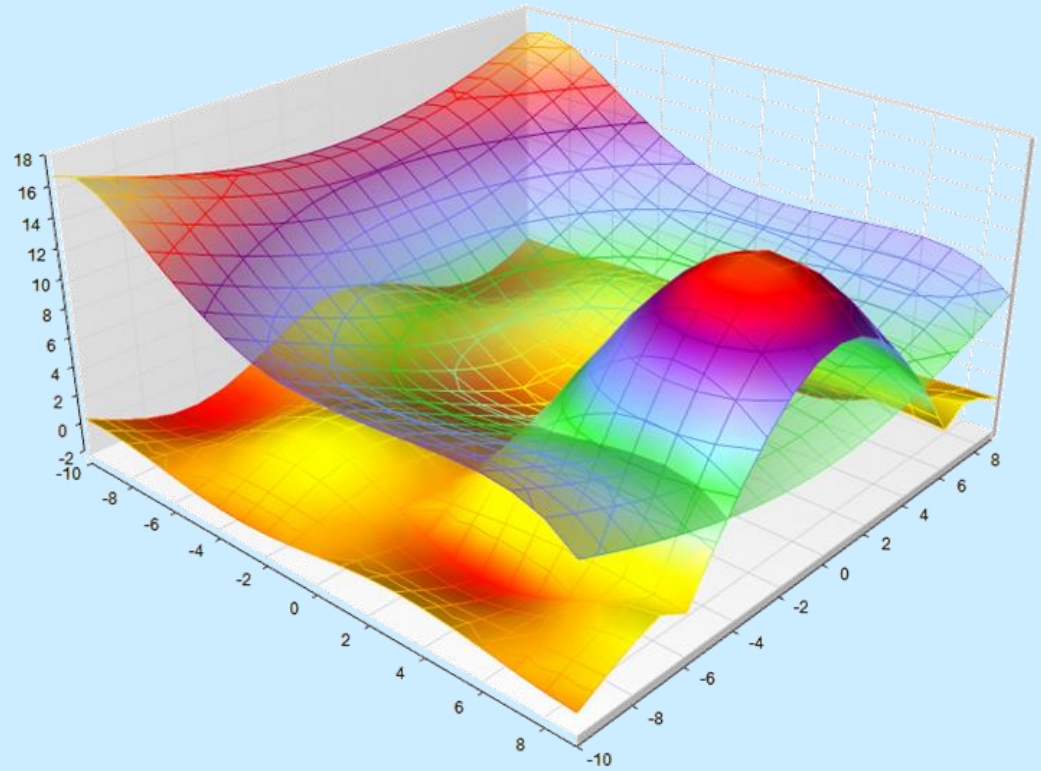
Prognostic FingerPrint[®] Technology



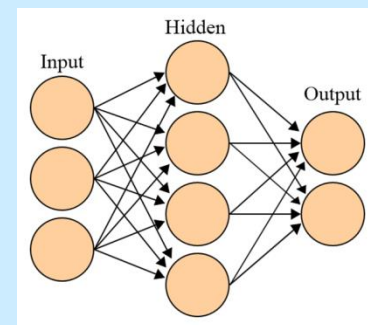
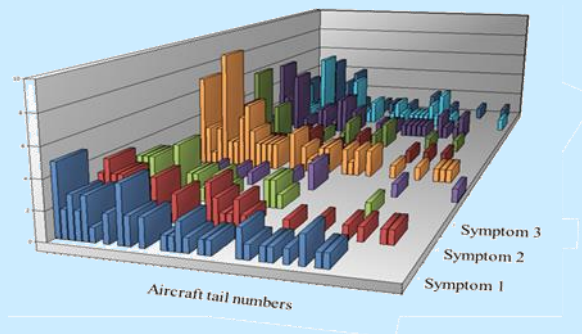
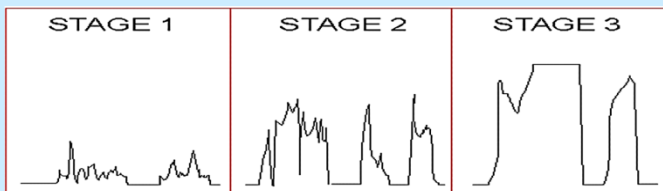
Vector Indicators
Matrix of Voltage,
Current, Power,
Time, Phase ,
Frequency



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



How.....



AA&S 2017
(Australia)



& Why.....

**Repeat
Faults**

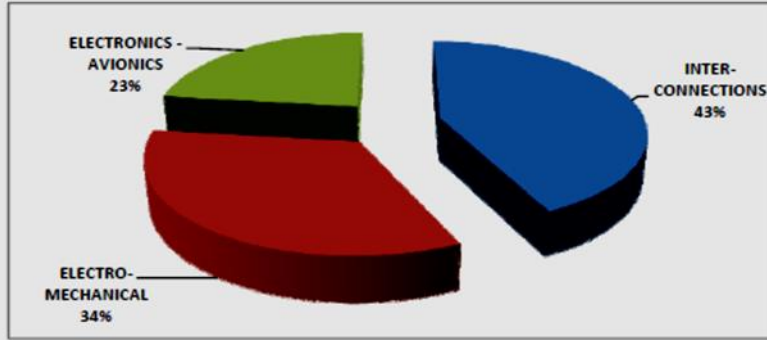
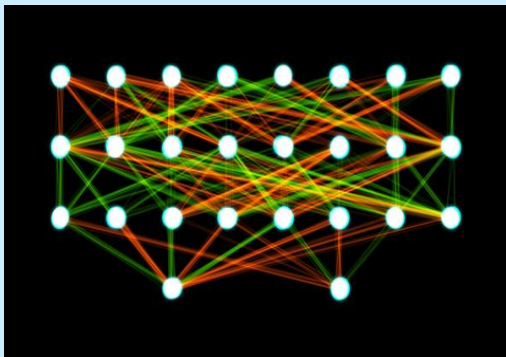


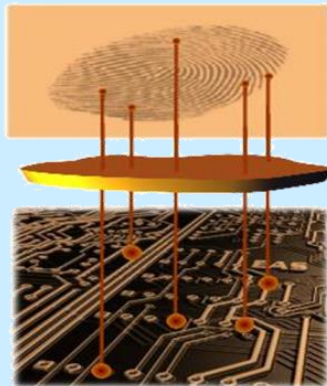
Figure 4- Occurrences of Electrical Failures by Classification³.





WHICH PARTS DID **YOU** PAY ATTENTION TO?

[What are the exams for success?]



Vector Map

Processing Layer

Data Acquisition

And for the
Future.....
FingerPrinting©



AA&S 2017
(Australia)





Expose the Disappearing Symptom



- Use Technology to Find the “glitches”.
- Grow the Business.
- I began with.....



- and with the application of **smart technology**, the Plan is to end with.....

more....





- 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.



John.baker@copernicustechnology.com

+61 3 9486 5872 M+61 412 831 410

