NOTE: It is the intention of this paper to form the basis of an article for trade magazines such as Aviation Week, Janes Defence etc. or form the basis for a technical conference paper.

'Hanger to Flight Line'

DRS Non intrusive On Aircraft End To End Test (ETET) Equipment – '*the discriminator in confirmation of mission readiness and operational capability*'.

1.1 **Introduction**

1.2 The conventional Automatic Test Equipment (ATE) community grew from the need to isolate faults in systems down to the Line Replaceable Unit (LRU) level or, as in some cases, down to the component level either ambiguously or unambiguously. The emphasis was on fault isolation, not confirmation of mission readiness. The migration to integral built in test (BIT), on board vehicle health monitoring systems, hardware intensive test architectures, compact testers and virtual instruments as well as the migration from diagnostics to prognosis has done nothing to change the fundamental paradigm of fault isolation. The Achilles heel of this philosophy is the fundamental belief that if all the sub assemblies or LRUs are operating to or within specifications, then the overall equipment will be operationally functional and fit for purpose for what it was designed to do.

1.3 Passing a system Built In Test (BIT) does not ensure a system is fully functional and operationally ready for use. There are always components within a system that are not fully tested by BIT but are critical to the overall performance of the system. Therefore, no matter how sophisticated the system BIT there will always be a BIT gap albeit possibly only 10% of the system not being tested. But this small percentage gap could be an antenna or Radio Frequency (RF) cable failure thereby making the overall system operationally ineffective.

1.4 The issue of operational effectiveness and possible BIT gaps in systems was raised following the first Gulf war when questions were asked about the functionality of these systems and their ability to detect and protect against threats. Following different studies it was concluded that a test in addition to the BIT was required to ensure all platforms in a threat environment were adequately protected so as to correctly discharge the care and responsibility aspects of the authority committing those assets into the threat environment.

1.5 The outcome of these studies is a non intrusive test system using small easily fitted RF hoods to the platform antenna systems. The RF hoods are fed with threat signals from programmable threat generation equipment which stimulates the systems under test. If the system is working correctly the threats are seen in the cockpit, heard in the pilot's headset and displayed on the platforms databus. If fitted with a jamming system the power and modulation type is also recorded. Therefore, following this non intrusive test the operators and maintainers can be sure that the platforms systems are fully operational and mission ready thereby discharging the care and responsibility issues of authorizing a platform to operate in a threat environment.

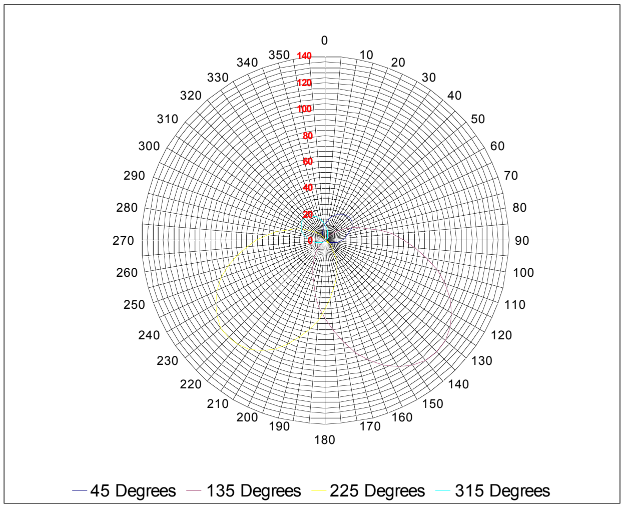
1.6 When the DRS developed non intrusive testing was introduced into platform maintenance schedules, other unforeseen but very significant advantages were found to be gained, with the most important of these being the marked improvement of platforms operational performance. The other advantages of ETET testing are listed as follows:

a. No Fault Found Rates (NFF) were reduced by factors of 25%. This was due to antenna and cable faults being identified quickly. Prior to non intrusive testing functional LRUs were being replaced in order to attempt to rectify reported faults.
b. Historical non intrusive test results has provided maintainers with system degradation data. This has proved instrumental in modifying servicing schedules and saving maintenance time and money.
c. System software upgrades could be demonstrated to a customer on a platform of choice without the requirement for a simulation rig.
d. Squadron operational effectiveness was improved as aircrew could be certain of system operability prior to trials, operational or training missions prior to flying.

2.0 **A Picture Saves a Thousand Words**

2.1 Following the introduction of non intrusive testing, the concept of how to display the test data so that it is easily interrupted was addressed by the user community as the data can be displayed in many forms and has different meanings to the authority reading it. What was required was a simple method of showing aircrew and engineers an unambiguous readout of the operational effectiveness of particular platform systems. This was achieved by taking the test data output and putting into a format that could be loaded into a readily available commercial software package. Readily available commercial software was deemed essential as industry bespoke software would have very limited machine readability and it was deemed essential that the data could be read and manipulated by all key squadron personnel on their standard PCs.

2.2 The test results from the non intrusive testing are displayed as system sensitivity relative to each antenna station; transmit or receive. Using this type of graphical display a defective quadrant can easily be recognized. Figs 1. and 2. show the output of non intrusive testing of a platform Radar Warning Receiver (RWR). Fig 1. is a faulty system even though the BIT passed the system as being functional. Fig 2. is the same system but fully operational after corrective maintenance had been carried out.



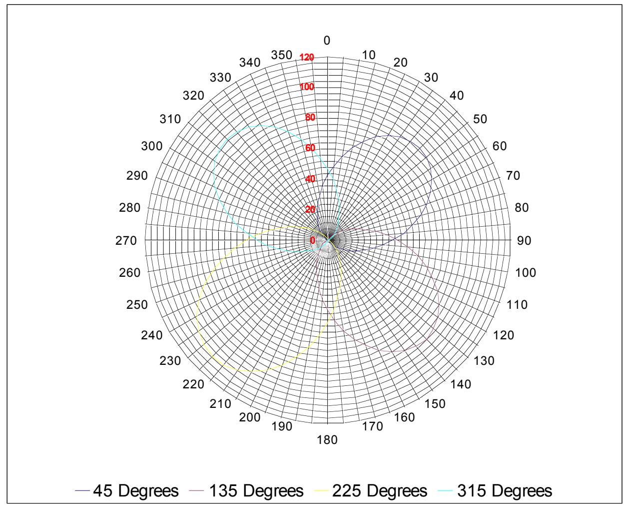


Fig 1. Defective forward hemisphere detection

Fig 2. Repaired system showing good quadrant sensitivity.

Note: The size of the lozenges in the Figs 1 and 2 represents the system sensitivity across the frequency bands. Even though Fig 2 shows a functional system not all quadrants have the same sensitivity. This clearly shows system degradation. Maintenance can be scheduled to rectify the system.

Note: The data in the figures above are representative and do not depict real system performance. These diagrams can be made bigger for an actual publication.

3.0 Non Intrusive Test Equipment

3.1 Non intrusive test equipment comprises three major elements; RF hoods designed to fit over platforms antennas. Signal generation and measurement equipment and bespoke application software. The ETET equipment as produced by DRS is further divided into three tiers of equipment. These equipment tiers are designed to cater for a customer’s budget and complexity of test requirements.

3.2 TIER One ETET Equipment

ETET Equipment: Full capability ruggedised military use.

a. Signal Generation and Measurement Equipment. Controls signal output/input to all RF Hoods automatically. Can measure RF cable losses. Complete software test package.
b. Hand held terminal. Provides ETET control/interface and a data bus monitoring capability.
c. Full Set of RF Hoods. Each RF hood fits a platform antenna system.


3.3 Current Customers

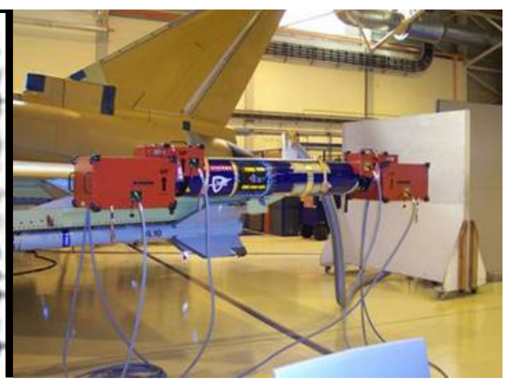
DRS Tier One test equipment is supplied to the following customers:

a. UK MOD. Eurofighter Typhoon, Harrier, Tornado. Hercules, Sea King, Chinook and Merlin.
b. German Air Force. Eurofighter Typhoon.
c. Italian Air Force. Eurofighter Typhoon.
d. Royal Saudi Arabian Air Force. Eurofighter Typhoon.
e. Royal Netherlands Air Force. F16.

3.4 TIER TWO

ETET Equipment. Full Capability non-ruggedised, sheltered operation

a. Signal Generation and Measurement Equipment. Controls all RF Hoods automatically. Can measure RF cable losses. Complete software test package. COTS Test equipment is fitted in a 19” rack which provides protection to the COTS instruments.
b. Hand held terminal. Provides control/interface and a data bus monitoring capability.
c. Full Set of RF Hoods. Each RF hood fits a platform antenna system.

3.5 Current Users

DRS Tier two test equipment is supplied to the following customers:

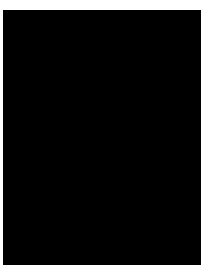
a. BAE Systems, UK
b. EADS - D, Germany
c. EADS - CASA, Spain
d. Alenia, Italy

3.6 TIER THREE

ETET Equipment. This Tier of equipment is designed for the flight line, field service representatives and customers who require an ETET capability without buying the Tier one or two level of equipment.

a. RF stimulation. Provided by hand held 'Squirt Gun' with adaptation to power RF hood/hoods using RF cable. This combination will provide 'Free Space' and RF hood testing.
b. Electro-optical module - addition to the 'Squirt Gun'. This will provide the option to test electro-optical systems such as electro-optical Missile Approach Warner (MAW) and LASER warning systems.
c. Stand alone RF MAWs test unit. This unit consist of MAWs hoods and control unit to test RF MAWs.
d. RF Hoods. Limited set of RF hoods. Enough hoods to test the system and safely limit RF transmission from the system under test.
e. Hand held monitor. To read 1553 bus and check Line Replaceable Units (LRUs) status.
f. Cable tester. Commercial cable tester to measure RF cable losses.

3.7 The Tier 3 combination of test resources will enable a full system check be completed manually, each antenna configuration will be tested separately. However, this configuration will provide the customer with an ETET capability that will enable them to isolate system faults including antennas and cables etc.



Hand Held 'Free Space' Generator – 'Squirt Gun'

RF Hood / Hoods

Lap Top Bus Monitor

Commercial cable tester

3.8 **Customers**

a. User of systems that require a non intrusive test capability.

4.0 **Summary**

4.1 Platform Avionics equipment has evolved and uses Automatic Test Equipment (ATE) and Built In Test (BIT) to determine faults. However, no matter how sophisticated a system BIT, there will always be a BIT gap. Following the first Gulf war, a method of closing the BIT gap was identified as being required to ensure platform operational effectiveness. The method chosen to close the BIT gap is called End To End Testing (ETET) and is based upon small Radio Frequency hoods that fit over the platform systems antennas. These hoods are then stimulated using signal generation and measurement equipment. The operation of the system under test can then be verified by either cockpit displays, warning tones in headsets or databus readings where available.

4.2 With the introduction of ETET the following benefits were also found to be gained; No Fault Found (NFF) rates reduced, system degradation could be monitored, systems upgrades demonstrated on customer platforms of choice, platforms instead of rigs and it could be used for training.

4.3 Following detailed discussions with the ETET user community, a graphical output of the test results was developed. This graphical output clearly demonstrated the operational functionality of the systems under test.

4.4 To enable any customer who requires ETET a family of test equipment classified into tiers has been developed ranging from Tier1 equipments such as that used by the Eurofighter community through to Tier 2 equipment used by commercial companies to test systems prior to customer deliver to Tier 3, flight line test equipment used as a final Go/NoGo check or testing using single hoods instead of a complete set.