Neural Engineering Utility with Adaptive Algorithms

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ABSTRACT

The Neural Engineering Utility with Adaptive Algorithms (NEUWAA) is a machine-based intelligence system for Automatic Test Equipment, which integrates various technologies in an Adaptive Fault-Detection Environment. Computer enhancements and mathematical algorithms allow for the use of man-machine and intelligent applications that were up to now, only dreamed about. The human/machine interface optimizes the test environment by providing State-of-the-Art Adaptive Algorithms to streamline test sequences and diagnostics. NEUWAA employs state-of-the-Art diagnostics methodologies coupled with self-organizing evolution to provide an efficient test environment at any level. Highlighted visual images with dialogue of the Unit Under Test provide interactive fault-isolation including guided-probe sequences to streamline fault/diagnosis. The system is completely interoperable with all other standard software packages. This paper outlines the Neural Engineering Utility with Adaptive Algorithms system including its various characteristics and the techniques involved in its creation.

INTRODUCTION

Off-the-shelf operating systems (i.e. DOS, UNIX, WINDOWS and TOOLBOOK) provide a high-performance platform for machine-intelligent implementation of integrated technologies for Automatic Test Equipment. Open architectures in an integrated technology environment permit the integration of multiple information sources for diagnostic evaluation of a Unit Under Test (UUT). Intelligent software/hardware provide dynamic Test Program control, real-time interactivity, interoperability, multiple languages, highlighted visual images and other user-friendly special visual effects, graphics, image processing, adaptivity, conversation, and automatic data collection. Integrated Technology provides a system whereby sensors other than ATE embedded devices (IR, X-Rays, etc.) are coupled into the ATE/Test Program to enhance the diagnostic process and streamline the repair cycle. This paper outlines the Integrated Technology package by outlining its various characteristics and the techniques involved in its creation.

PROBLEM

Traditional test programs are sequential, non-interactive, lack facility to weigh multiple information sources, and are unable to adapt, even when erroneous software prognoses can be clearly identified. Interoperability is not supported. These programs also lack capability for test program maintenance and development, which must usually be done on a different platform by a test program engineer. This adaptive system acts as a meta-processor for the test program, creating an adaptive, integrated technology test environment with man/machine interaction including conversation[2]. The layout of the open-architecture interoperable environment is displayed in Figure 1.

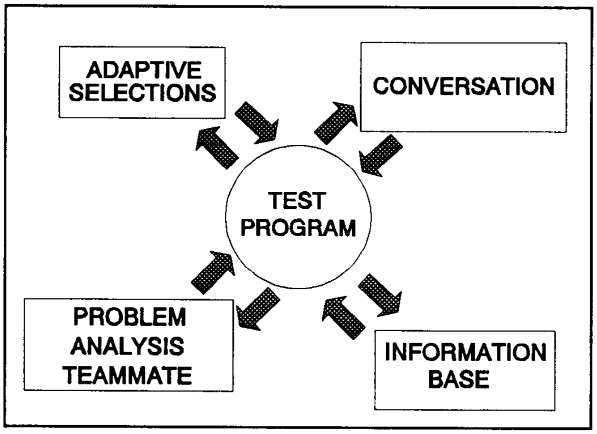


Figure 1. Open Architecture Environment.

INTEGRATED ATE PLATFORM

There are various technologies which can provide UUT functional information other than the standard electronic stimulus/response of the Automatic Test Equipment as shown in Figure 2. Using information from other technologies enhances the UUT diagnostic evaluation. Opinions derived by other technologies about the UUT functionality are integrated together to form an optimal test/repair strategy as shown in Figure 3.

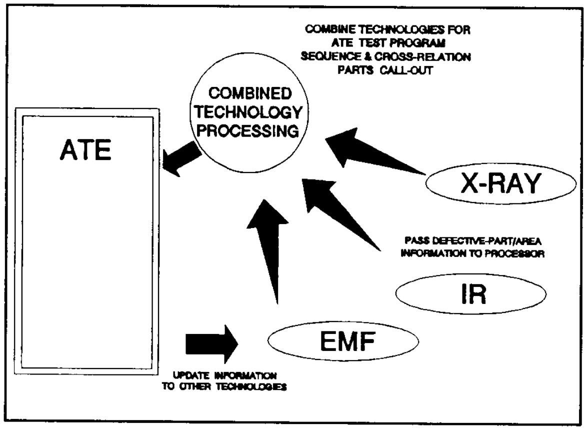
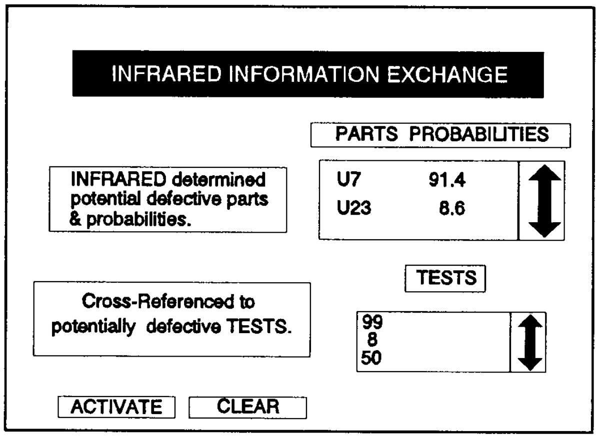


Figure 3. Combined Technology Processing.

Communications between systems is achieved by a standard ontology of common terms to represent sensor and sensor-based signals in Knowledge-based Learning Systems. Ontology provides a lexicon of common terms, providing the users with a common dictionary of standard labels and units which have a precise, well-defined meaning, independent of the internal or individual processing system. The Sensor-based Ontology is an ATE-specific ontology which provides for interoperability between different software packages, testers, sensors, and Instruments on a Card (IAC). Interoperability is talking the same language, using the same terms, and inferring the same meaning; so no matter what internal or individual system processing is used at least the conveyance of sensor-based information will be understood. Essentially, interoperability is the ability to communicate between software packages and understand what is said.

As an example, the IR system identifies performance information for marginal parts and candidate defective parts. This information is then sent to the Combined Technology Processing System. The Combined Technology System takes this information and cross-references the parts to potentially defective ATE UUT tests as shown in Figure 4.



INFRARED determined potential defective parts & probabilities.

U7	91.4
U23	8.6

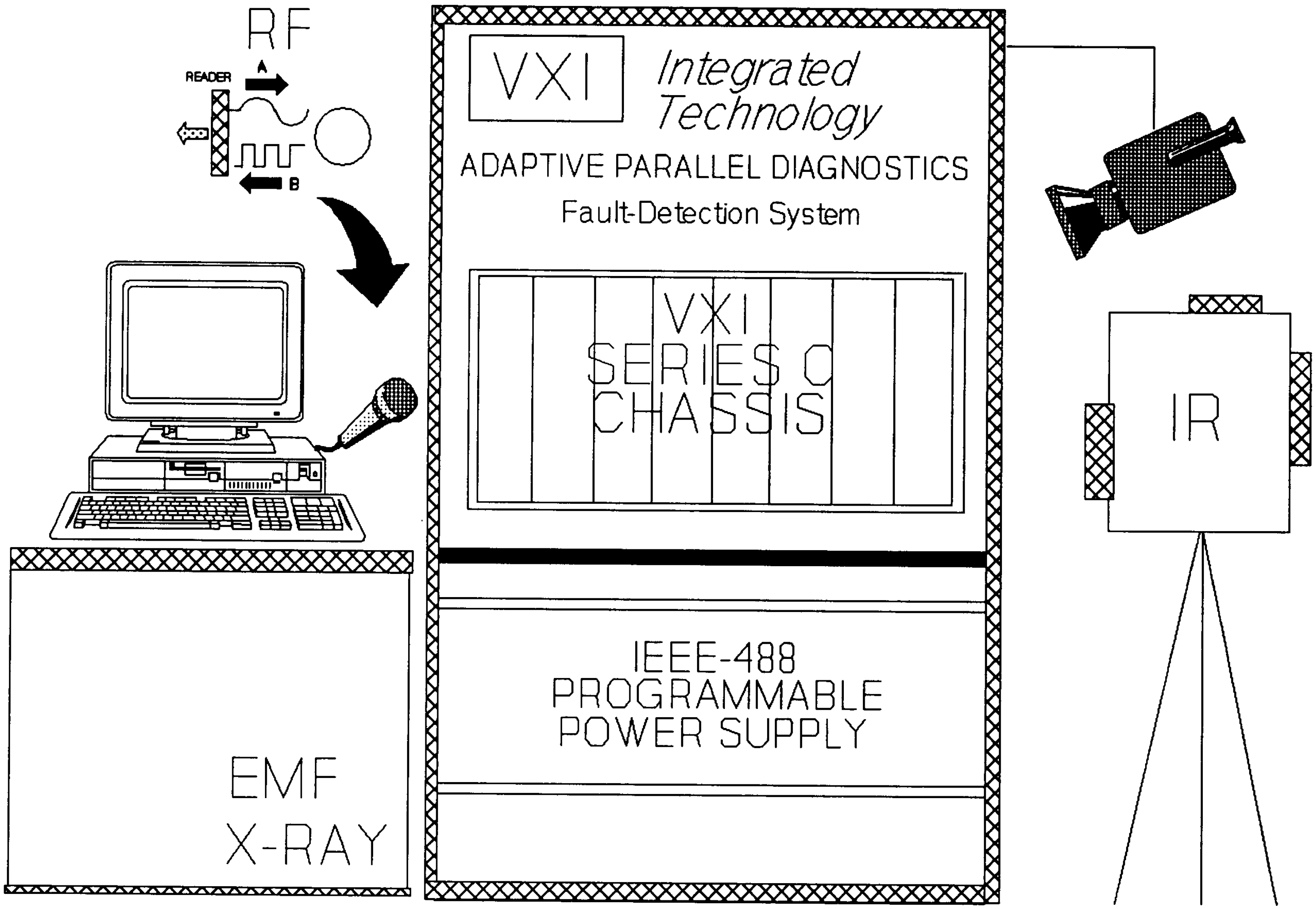
Cross-Referenced to potentially defective TESTS.

99
8
50

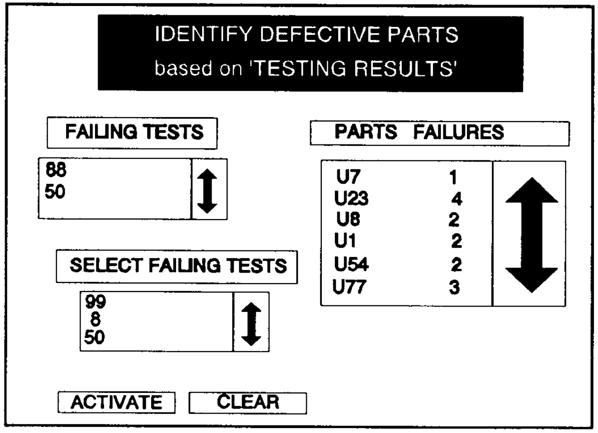
Figure 4. Infrared Information

The potentially defective ATE UUT tests can then be cross-referenced to the module "IDENTIFY DEFECTIVE PARTS, based on 'TESTING

Figure 2. Integrated Technology ATE



RESULTS'". This module will indicate other potentially defective parts as shown in Figure 5.



IDENTIFY DEFECTIVE PARTS
based on 'TESTING RESULTS'

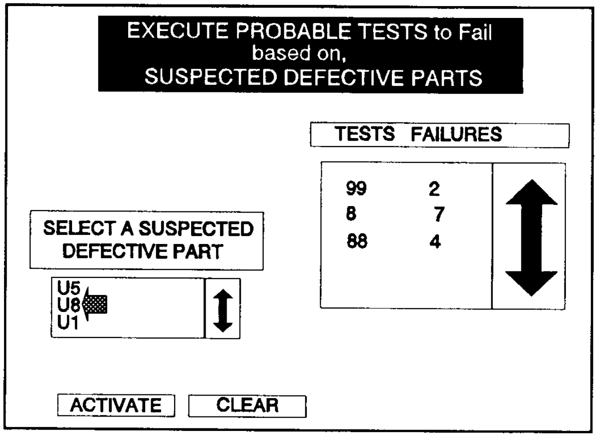
FAILING TESTS
88
50

PARTS	FAILURES
U7	1
U23	4
U8	2
U1	2
U54	2
U77	3

SELECT FAILING TESTS
99
8
50

Figure 5. Testing Results.

These Parts can then be cross-referenced to other ATE UUT tests by executing the "EXECUTE PROBABLE TESTS to FAIL, based on 'SUSPECTED DEFECTIVE COMPONENTS'" as shown in Figure 6.



EXECUTE PROBABLE TESTS to Fail
based on,
SUSPECTED DEFECTIVE PARTS

TESTS	FAILURES
99	2
8	7
88	4

SELECT A SUSPECTED DEFECTIVE PART
U5
U8
U1

Figure 6. Suspected Parts.

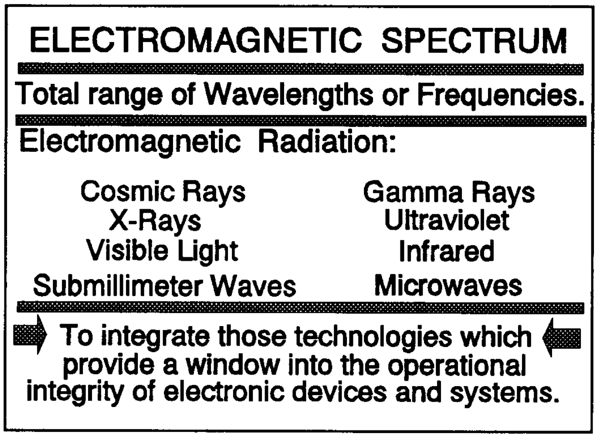
These other tests can be executed to aid in fault determination should the other information prove useless. Similar routines are executed for other technologies such as X-Ray, however different factors are used such as X,Y coordinates.

The system provides cross-reference tests & defective part schemes, so the user can have multiple information avenues available for fault determination.

The technologies presently configured into the open architecture of the ATE include:

- Infrared Technology
- Electro-magnetic emissions detector
- Speech & Audio
- RF reader
- Vision
- X-Ray
- Sound (vibration)
- Knowledge-bases
- Kerr Electro-optical Magnetic-electric effect

The purpose is to integrate those technologies in the electromagnetic spectrum which can aid in test & diagnosis, refer to Figure 7.



ELECTROMAGNETIC SPECTRUM

Total range of Wavelengths or Frequencies.

Electromagnetic Radiation:

Cosmic Rays
Gamma Rays
X-Rays
Ultraviolet
Visible Light
Infrared
Submillimeter Waves
Microwaves

To integrate those technologies which provide a window into the operational integrity of electronic devices and systems.

Figure 7. Integrated Optical Technologies.

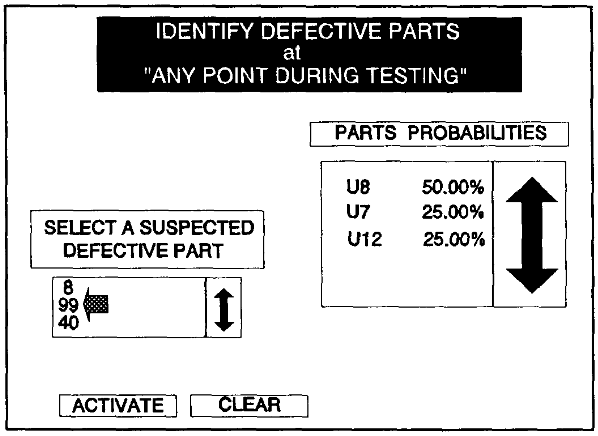
Information derived from the Infrared, EMF, X-Ray technology is used to direct the ATE to the optimal test to verify a failure and co-ordinate opinions about the failing component. When diagnostic determinations are presented the operator is provided with opinions derived from the entire information base.

Speech is used to provide the operator with pertinent information during test processes. Speech is also used to allow the operator to verbally command program flow. Vision is used for UUT examination and visual fault detection.

A principal source of error in ATE is data entry by the technician. Reliable UUT identification is achieved by using RF identification integrated chips mounted on the unit. RF/ID technology requires only proximity of a reader for a successful read. RF/ID readers require no specific orientation to function. The reader generates a magnetic field which activates the RF integrated circuit(IC), then the IC transmits its unique code back to the reader's receiver. The receiver processes the signal and forwards it to the microprocessor where it is converted to a specific format.

ADAPTIVE ALGORITHMS

The system's Adaptive Algorithms for pre-test, test selection, and predictive diagnostics are available for multiple cross-referencing. The Adaptive Algorithms provide a cross-reference of information during ATE testing. The cross-referenced information allows the user to decide on various test/diagnostic schemes. An example of a test/diagnostic scheme is as follows; say Test 8 fails and the user selects the module 'IDENTIFY DEFECTIVE PARTS at "ANY POINT DURING TESTING"' as shown Figure 8.



8
99
40

U8	50.00%
U7	25.00%
U12	25.00%

Figure 8. Defective Parts during Testing.

The user can then cross-reference the defective parts to the module 'EXECUTE PROBABLE TESTS to FAIL based on, "SUSPECTED DEFECTIVE COMPONENTS"' as shown in Figure 6. These tests can then be executed to determine other possible defective parts.

ADAPTIVE TEST SEQUENCE CONTROL

Prior to the performing any testing, intelligent decisions can be made to minimize testing time, and to obtain the most information from the tests performed. These decisions are based on the information collected at the test station, providing adaptability to situations not anticipated by the software programming engineer. Special selection menus are presented which give the operator several options for unique and individually preferred test/repair processes. Specific pre-test options include:

- Test selection based on "Reason for Repair"
- Tests likely to fail "GENERAL"
- Probable Defective Components "GENERAL"
- Probable Defective Components based on "Reason for Repair"
- Directed search in a known "Bad Signal Path"

ADAPTIVE FAULT RECOGNITION

In a traditional *rule-driven* repair scenario, the software will continue to call for the replacement of the same part even after the part has been replaced. Our system achieves adaptability by including historical information, collected at the test station, to augment the traditional rule-driven algorithm. Specific alternatives to normal defective part call-outs include:

- Identify component failure probabilities
- Identify defective parts, based on "Testing results"
- Identify defective parts, based on "Reason for Repair"
- Identify defective parts, based on "Bad signal path"
- Identify defective parts at "Any point during testing"

These recommendation are based primarily on absolutes like Tests, Components, and Reason for Repair rather than abstract and often incorrect measurements made by the sensing equipment. None-the-less, the correct call-out may in fact be identified as the "second most" probable call-out. Rigid adherence to the decision recommended by the rule-based systems can result in inefficient testing, and can result in the inability to obtain the best decision. Introducing chaos can therefore improve the effectiveness of the overall repair process.

TESTING STRATEGIES

Traditional *rule-driven* machine-based intelligent algorithms deal with assigning probable outcomes associated with a given set of information. These algorithms give no clue as to how to conduct a testing strategy. Specific alternatives to normal sequential test execution include:

- Execute tests with highest probability of failure
- Execute next best test based on "testing results"
- Execute next best test based on "Failing tests".
- Execute probable tests to fail, based on "Reason for Repair"
- Execute probable tests to fail, based on "Suspected defective components".
- Execute probable tests to fail, based on "Component failure probabilities".

In many applications, the available information is insufficient to obtain an exclusive decision. Genetic Algorithms employed in the Test Selection scheme enable to software to eliminate non-productive testing strategies through the process of simulated natural selection. Genetic Algorithms are search algorithms based on the mechanics of natural selection and natural genetics[1]. Chaos in the underlying genetic algorithm simulation is employed to introduce alternative information, and to obtain a viable testing sequence strategy.

CONVERSATION

The Conversation module provides a method to link to alternative technologies and software tools. Communication between instruments and software programs is provided in terms of a stream of ASCII characters, with appropriate labels, such as "Volt", "watt", and drawing part identification. An ontology of standard terms provides a context-free interpretation of intermediated results. This system provides an open architecture for existing *and future* software modules and instruments in an interoperable habitat. Conversation has a programmable function selection sequence option so the operators can create their own peculiar testing scheme.

Conversation is the open loop habitat which couples all surrounding software packages into an integrated cross-reasoning environment. Inter-operability issues like how programs communicate, how sentences are structured, and exactly what is communicated are employed to make an on-going state-of-the-art updatable package.

In a world of multiple biological and mechanical reasoning systems, it is wise to share ideas, senses and knowledge between them. Marvin Minsky stated that we should build intelligent systems[6] and put them to use. The Conversation module is intended to provide the link between all systems and thus supply the UUT operator with a combined solution scheme.

EMERGENT CONCEPTS

Emergent concepts are used whenever possible to optimally perform tasks. Everything in the universe is governed by chaos in one way or another. Chaos is sometimes perceived as an erratic derivation in flow, however this is generally not the case. There is more than one way to get from point A to point B. The optimal way is not always the cut and dry solution that so many systems tend to conclude but rather can be a varied way with unknown factors having a greater influence on direction. Concepts like Genetic Algorithms, Lindenmayer systems, and Cellular Automata are used to generate, maintain and optimize operational processes.

There is a significant relationship between biological neuronal systems and artificial neuronal systems. To emulate the brain's powerful thinking and problem-solving capabilities a computer model that matches the functionality of the brain is used. This computer model is the Neural Network[3]. The Neural Network is used to predict precise limits and nominal values for guided-probe sequences, problem analysis routines, and specific probe-points/outputs.

PROBLEM ANALYSIS TEAMMATE

This module uses digitized UUT layouts (Functional blocks, schematics, etc.) and provides highlighted visual images with dialogue for a complete interactive fault-isolation test environment. The module contains a Neural Net based guided-probe sequence which supplies optimal/selected probe-points for quick and completely accurate fault-isolation.

This module provides schematics with specific probe-points. Probe-point boxes will appear at the operator request and will contain the trained optimal or good measurement data plus a list of parts for specific out of tolerance measurements, i.e. Figure 9.

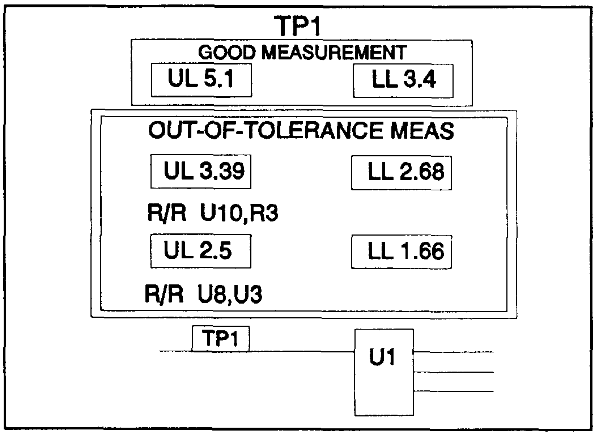


Figure 9. Problem Analysis Teammate.

This module interacts with other modules when fault analysis probing is required.

VIRTUAL REALITY INTERFACE

The system operates in a WINDOWS / TOOLBOOK environment with super user-friendly interaction techniques. The object-oriented graphical information displays are assimilated more rapidly, readily understood and retained longer. The operator response time to queries is significantly reduced and the windows system provides a real-time flow between the human and the machine. Graphical displays are readily integrated and easily altered. Pictorial information for human interpretation and processing[5] improves through-put by magnitudes of order.

Analogous to Einstein's theory of relativity where what is seen is a function of the position and velocity of the observer. Virtual reality exists within the memory of the computer, which contains all the attributes of an imagined or real environment, including control panels, switches, fader bars, oscilloscopes, and virtual video displays. Virtually realistic images which act in a specific manner (both moving and stationary) and represent the environment are located within the system — eliminating the need to procure and integrate supplemental testing equipment.

MINGLING

Sensor-based systems for test/diagnosis cover a larger range than the typical stimulus/reaction associated with ATE. ATE operating systems should be open so as to allow integration of other sensors and provide information exchange about UUT failures.

Open Architectures keep the door open for technology integration. State-of-the-Art software/hardware can be readily integrated in an open system without changing the existing system. No longer can the technical world isolate themselves into a never ending system overhaul requirement every time a system needs to be upgraded.

Mingling technologies gives the repair technician a much broader window of information about the UUT. Giving the technician more information about the functionality of the UUT is not like committing the unforgivable sin. The more information operators are given, the more they will understand the UUT and begin to equate specific characteristics about the UUT, thus enhancing their ability to perform repair.

CONCLUSION

This combined technology system provides the tools needed for repair process improvements and operator support. Closed systems which can not communicate with the outside world hinder technology breakthroughs and blind the technician to other pertinent information. Depriving the technician of information to aid in the test/diagnosis of a UUT is counter-productive to a cost effective quality work environment. For example, the Infrared system can detect heating problems and inform the user to shut-down power before UUT damage can occur. An intellectual challenge of the highest order[4] is to continue to develop and integrate all technologies which can be beneficial to the test/diagnosis world.

The intent is to open up the ATE systems and provide an avenue for all technology integration and inter-operability.

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