

# ATE Obsolescence Solutions; Costs and Benefits

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**Abstract - Test equipment obsolescence is a serious problem in DoD Automated Test Equipment (ATE) systems today. Test instruments are routinely integrated into ATE that are used by the services at all maintenance levels from flight lines for routine maintenance to depots for major overhauls and factories for production and acceptance testing. Often ATE systems are required to operate for years, sometimes decades. In many systems the instruments are now reaching end-of-life and are failing at increased rates. Exacerbating this problem, critical components necessary to repair the original instruments are often out of production, rendering the instrument obsolete and unsupported. As a result of these factors, many complex ATE instruments have become, or are destined to become the problem-prone “system degraders” tracked in ATE program reviews. This paper will present data on the magnitude of obsolescence challenges facing the DoD, an overview of the costs and benefits of current approaches used to solve the problem in comparison to the composite replacement instrument approach.**

## I. INTRODUCTION

Fifty billion dollars (\$50B) were spent on (DoD) related Automated Test Equipment between 1980 and 1992. Over the lifetime of this equipment, costs are expected to exceed \$250B. Aging test equipment obsolescence is a serious problem in DoD Automated Test Equipment (ATE) systems today. Test instruments are routinely integrated into ATE systems that are used to test everything from commercial aircraft to cell phones. Often ATE systems are required to operate for years, sometimes decades. In many systems the instruments are now reaching end-of-life and are failing at increased rates. Exacerbating this problem, critical components necessary to repair the original instruments are often out of production, rendering the instrument obsolete and unsupported. As a result of these factors, many complex ATE instruments have become, or are destined to become the problem-prone “system degraders” tracked in ATE program reviews. System degraders have huge cost impacts for the DoD. For example the Navy’s AN/ASM-608 tester, supporting the F/A-18’s inertial measuring unit, needed 525 repairs in 1999, requiring 4792 man-hours of service labor. Many of these repairs were traceable to obsolete test instruments. This extra service labor is expensive and the downed test station is even more costly.

## II. BACKGROUND/TYPICAL ATE SYSTEM:

Figure 1 is a diagram of a representative DOD ATE system. These systems are typically multi-rack assemblies consisting of commercial off-the-shelf instrumentation, custom circuitry, interconnecting cables, switches and a controlling computer. Testing is performed in an automated or semi-automated sequence via Test Program Sets (TPS) running on the controlling computer. The racks are designed to support test and maintenance of numerous Units Under Test (UUT). Because each UUT is different, custom fixtures are used to mate to the UUT.

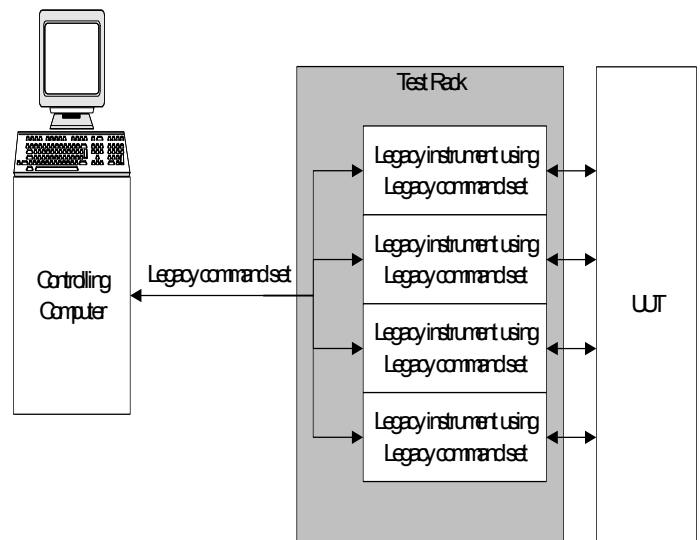


Figure 1 Typical DOD ATE System

The TPS on the controlling computer controls the test and all of the instruments in the system via a control interface bus. Control commands are sent to instruments via the control interface bus and measurements are gathered from the instruments over this bus. All ATE utilize a bus of some form factor including Binary Coded Digital (BCD), RS-232, General Purpose Instrumentation Bus (GPIB)<sup>1</sup>, and VME Extended Interface (VXI) with the bulk of legacy ATE utilizing the GPIB bus for remote control communication.

<sup>1</sup> IEEE Std 488.2-1992: <http://standards.ieee.org>

The application interface on the ATE's controlling computer is the TPS. TPS's are specialized software applications usually comprised of compiled ATLAS code. As each UUT is different, there are numerous TPS's deployed on a typical ATE system. Under the TPS is a driver layer that translates the generic measurement functions into specific instrument command strings for each instrument in the system. Beneath the driver layer is the I/O layer that communicates directly with the bus controller. The bus controller is the hardware device that actually transmits the signals over the bus. Figure 2 illustrates the various software layers involved in a typical DOD ATE system.

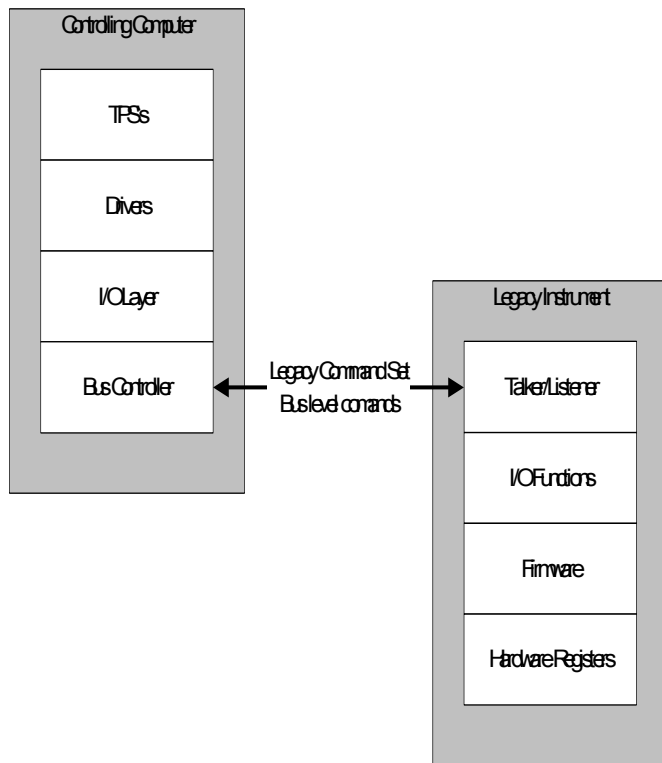


Figure 2 Typical DOD ATE Software Layers

### III. PROBLEM STATEMENT:

COTS (commercial off-the-shelf) instruments would ideally replace these obsolete legacy instruments, bringing test station reliability back into the useful-life portion of the bathtub reliability curve.

However, COTS instruments present several challenges:

1. Incompatible communication protocols and different communication busses

2. Functional differences in the way new instruments operate
3. Mechanical packaging differences
4. Differences in calibration and maintenance procedures

Collectively, these differences make it extremely challenging and expensive to integrate a replacement COTS instrument into an existing ATE system. Moreover, because of the extensive changes that are needed to accommodate the new instrument, the test station's test software (called TPSs -Test Program Set) must be modified and thoroughly revalidated to verify the new instrument is working properly. This revalidation is a significant cost driver in a COTS replacement effort, often requiring re-test of hundreds of individual test programs.

In the past decade the DoD has chosen to combat test system obsolescence by offloading TPSs to standardized test platforms like the Navy's Consolidated Automated Support System (CASS). TPS offload can solve obsolescence once and for all, by migrating the tests to a standard, well-supported test system. Offload has been successful in a number of instances, but it has also fallen short of its early promise for three reasons:

1. Offload is taking years longer than planned, in many cases *decades* longer than planned. This is due primarily to the cost and complexity of translating and revalidating TPSs – often requiring tens of man-years of engineering.
2. For some users, particularly United States Foreign Military Service (FMS) users, CASS systems are not available, thus maintenance must continue using the original test station.
3. CASS itself is starting to suffer from obsolescence issues. The system is well over a decade old now and the components used in the first generation are no longer in production and will begin to fail at increasing rates.

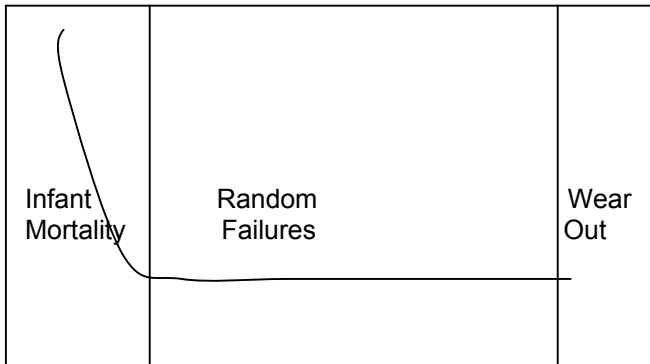
### IV. IDEAL BATHTUB RELIABILITY CURVE:

The bathtub reliability curve is a plot of failure vs. time, characterized by three regions in time.

1. Infant Mortality: An initial region characterized by a sharply decreasing failure rate. Failures are caused by defects occurring as result of substandard components and the lack of quality in the manufacturing process.
2. Random Failures: Random failures occur at a somewhat constant rate of the entire life of the product. Ideally, in a mature product, where the design and processes are good, the failures are usually due to the forces external to the

product, such as mishandling, external interface failures, or accidents. In the time period after infant mortality, but before the beginning of wear out, random failures dominate. This region is also called the useful life region of the product.

3. **Wear Out:** A final region of increasing failure rate when the product begins to wear out because it has reached the end of its useful life. As parts wear out, it takes less stress to cause failure and overall system failure rate increases.



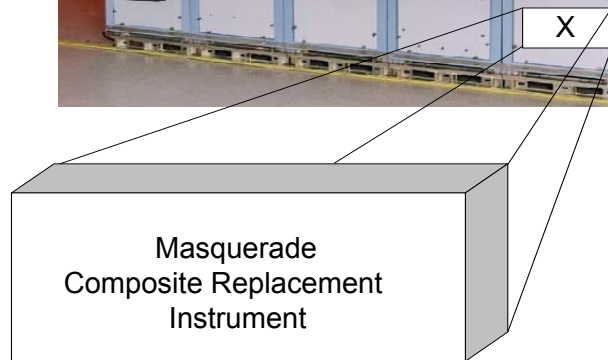
The ideal bathtub curve shown above reflects equipment that is replaced before wear out. For DoD ATE, the curve represented above is not a reality and alternative approaches dealing with obsolescence and increasing failure rates and costs are imperative.

#### V. CURRENT APPROACHES TO SOLVING OBSOLESCENCE:

Several approaches are being employed currently to combat instrument obsolescence. These approaches are listed below, along with potential drawbacks.

1. **Continued maintenance and repair.** In this approach the instrument is maintained and repaired, as is with the actual repair performed done in-house or outsourced. Frequently the outsourced repair is quite expensive, as the DoD customer is often the only user of the service. This solution – continued maintenance and repair – is functionally ineffective as shown by the prevalence of system downtime even with the high and ever-increasing maintenance costs.
2. **Procure replacements in the secondary market.** This can be chancy as the used instrument may be just as problem-prone as the one it is replacing. This is because most instrument failures at end-of-life are traceable to component degradation, due to a physical change, such as dielectric dry-out in electrolytic capacitors. Used instruments are likely to suffer from the same problems if they were manufactured at the same time as the failed instrument.

3. **Cannibalize systems to obtain replacements.** This approach looks good on paper, especially when a large number (but not all) of the in-service test systems are being decommissioned. It is tempting to stockpile the sidelined instruments to fulfill anticipated replacement needs for the remaining stations. This approach suffers from the same component failure issues as replacements procured in the secondary market.
4. **Lifetime Buy** is an effective approach however, like the above-mentioned solutions, this is a short term solution. Obsolescence is a reality and the lifetime buy approach may actually work against the DoD creating obsolescence situations where none existed. Given the reliance on a certain vendor, lifetime buy situations may leave the DoD in a poor negotiation position with lifetime costs higher than anticipated due to the economic factors at play with vendors, storage, and increasingly short product lifecycles.
5. **Procure a functional replacement.** This approach has been utilized effectively in a number of situations, including the AN/USM-484 Hybrid Test System mentioned in the previous section. This approach solves the end-of-life reliability issues, but it typically involves custom hardware and software that is expensive to develop, difficult to maintain, and does not protect against future obsolescence. Each replacement utilizes unique software; so non-recurring engineering costs are high.



Form, Fit, Functional Replacement

6. Off-load the TPS that the instrument supported to another test platform. This can be very expensive, especially where a large number of TPSs are involved. Because of the high cost, this approach usually takes years to implement. In fact, CASS offload schedules are now stretching well into the next decade. In addition, CASS has not been adopted for foreign military applications; these users will have to continue to maintain the existing stations.

DoD support logisticians facing one of the above unsavory maintenance choices or long waits for off-load would benefit from a composite replacement instrument solution.

#### VI. COMPOSITE REPLACEMENT INSTRUMENT:

Composite Replacement Instruments (CRIs) masquerade as the original/obsolete instruments, seamlessly replacing them in test systems – without requiring costly software upgrade or re-host. Composite replacement instruments provide the opportunity to extend the life of ATE systems, immediately improving reliability while reducing on-going support and maintenance costs. Composite replacement instruments are form, fit, functional, drop-in replacements for obsolete instruments in legacy ATE.

All CRI's are alike; comprised of a COTS test instrument(s), signal conditioning, a translation computer, and instrument-specific translation software.

#### Composite Replacement Instruments:

- Utilize COTS instrumentation as foundation
- Offer rapid, cost-effective, standardized approach leveraging reusable software and hardware components
- Preserve existing TPS investment
- Leverage IVI architecture for obsolescence prevention

The CRI's translation computer and signal conditioning act as a bridge between the new COTS instrument and the existing ATE system, making the CRI a true form, fit, and functional replacement for the obsolete instrument. CRIs perfectly duplicate the original instrument's remote control protocol to eliminate the need for expensive TPS modifications. A custom translation program handles this task. Traditionally, this translation program development is the trickiest and most expensive part of an obsolete instrument replacement effort, often requiring man-years of labor. Standardized components combined with software technology innovations including use of reusable component architectures (COM, .NET, and Java, IVI Drivers and IVI architecture defined by the IVI Foundation) accelerate development of CRI translations.

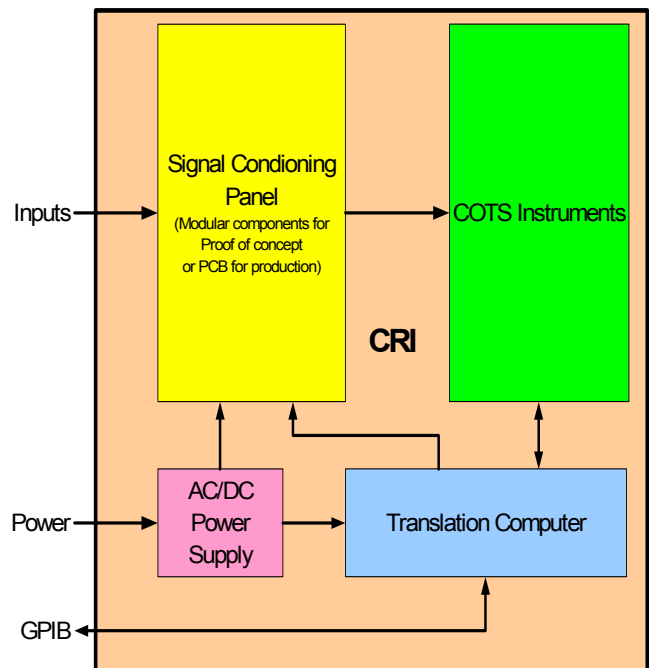


TABLE I.

A COMPARISON OF BASELINE TECHNOLOGY AGAINST COMPOSITE REPLACEMENT INSTRUMENTS

<b>Characteristic</b>	<b>Composite Replacement Instrument</b>	<b>Continued Maintenance (1,2,3,4)</b>	<b>Custom Functional Replacement (5)</b>	<b>Offload (6)</b>
Ongoing support costs	Low	High	Medium	Low
Engineering change cost	Medium	Low	High	High
Eliminates TPS update or migration cost	Yes	Yes	Possibly	
Minimal or no TPS revalidation	Yes	Yes	Possibly	Yes
Robust translation technology	Yes			
Simplified field support and upgrade	Yes			
Advanced IVI technology	Yes			
Form replacement	Yes	Yes		
Fit replacement	Yes	Yes		
Function replacement	Yes	Yes	Yes	Yes
Cost	Low	High	High	High

## VII. CRI USE CASES:

Composite Replacement Instruments present a viable alternative to other obsolescence approaches. CRI's are also favorable in the following specific applications.

- Test systems with instruments that are expensive to maintain because of a sole-source of supply. Often this supplier has no incentive to reduce costs in this scenario. This can lead to acute situations like that of the obsolete digitizer in the Navy's AN/USM-484 Hybrid Test

System. Prior to replacement, roughly \$1M per year was being spent to maintain 200 of the digitizers.

- CASS, in existence for approximately 15 years, is experiencing obsolescence in several of its instruments. These instruments could easily be replaced with Composite Replacement Instruments.
- Test systems that are no longer easily maintainable due to a discontinued product. When a vendor no longer supports a product, logisticians are forced to turn to secondary markets to get repairs or to obtain refurbished instruments. Often these instruments are of questionable pedigree.
- Test systems that contain non-standard, one-of-a-kind instruments. These instruments often involve specialized maintenance procedures and sole-source parts. In general, they are often less reliable than commercial counterparts. A Composite Replacement Instrument can replace the one-of-a-kind original, often eliminating tedious maintenance and calibration procedures. A good example of this is the AN/USM-467 RADCOM Signal Analyzer where the CRI eliminates dozens of manual calibration adjustments.
- Test systems that need to be replicated, but the original instruments can no longer be procured. In this scenario the original test system is not suffering from obsolescence, but it cannot be replicated due to an obsolete instrument.
- Test systems that are in queue for offload to a standard test system, but suffering unacceptably high maintenance costs and/or degraded readiness of supported military hardware.
- Depots supporting foreign military service activities that have need for extended life because migration to a standardized ATE such as CASS is not schedule or cost justified.

#### VIII. CONCLUSIONS:

Test equipment obsolescence is a serious problem in DoD Automated Test Equipment (ATE) systems today. Composite replacement instruments offer a viable alternative to current approaches for reducing legacy ATE lifetime costs offering the following potential benefits:

- Rapid, cost-effective, standardized approach leveraging reusable software and hardware components
- Reduced risk through TPS investment and ATE configuration preservation

- Obsolescence prevention through IVI-COM architecture

#### About Vektrex:

Incorporated in 1986, Vektrex is a software and systems integration company supporting the test and measurement industry. The company is focused on advancing measurement technology and migrating measurements from hardware; test instruments and test tubes, into software and the PC. Vektrex has established key expertise with test instruments, instrument drivers, and software based measurements and provides enabling products and services that help clients migrate to software-based measurements. Products include patent pending Masquerade technology enabling the rapid development of Composite Replacement Instruments (CRI); form, fit, function replacements for obsolete instrumentation in legacy ATE. Vektrex also produces software products focused on drivers and reusable software components including VIVID, the software development toolkit that produces IVI compliant COM based drivers. Vektrex' clients span advanced technology industries including defense, biotechnology, and semi-conductor. See Vektrex at [www.vektrex.com](http://www.vektrex.com).