AUTOMATED TEST EQUIPMENT SYNTHETIC INSTRUMENTATION

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***Abstract* –When the USAF's F-15 became operational in the mid-1970s, intermediate avionics test support was provided by specific test stations designed to support technology workload groups, ranging from controls and displays to communications/navigation equipment, with many of the test packages requiring complex Interface Test Adapters (ITAs). These testers are quickly becoming obsolete and more difficult and costly to maintain because replacement parts are no longer available. Alternative technical solutions are required to ensure fielded avionics test equipment technology maintains pace with fielded systems and operational requirements, ensuring the availability of mission critical avionics assets.**

In order to demonstrate a solution to these growing issues, Boeing is tailoring an emerging F-15 support system by inserting Agile Rapid Global Combat Support (ARGCS) technologies including Synthetic Instrumentation (SI), to reduce the use of traditional COTS (commercial-off-the-shelf) instruments. This type of arrangement will highlight the potential benefits of SI, which include the use of non-active (wire only) ITAs to the USAF. During the past decade the USAF has expressed a desire for this passive ITA hardware design, since it facilitates reduced development time, increases equipment reliability/availability and decreases long-term sustainment cost compared to the existing specialized complex active hardware design approach.

During this 12-month program, SI is being integrated into the selected ATE platform to provide analog, serial bus test and video capability by replacing existing VXI-based instruments. Several F-15 line replaceable unit (LRU) test program sets (TPS) are being integrated and/or adapted to use the SI-equipped support system, demonstrating the ability to rapidly prototype TPSs. By utilizing parallel testing capabilities of the latest technology synthetic instruments, a significant reduction in test times is also expected.

This paper discusses the engineering effort required to integrate SI into the selected ATE platform including the hardware and software design approaches employed, as well as the methodology used to re-engineer TPS designs to leverage SI and the benefits realized during the project as well as potential applications to DoD customers.

BACKGROUND

Traditionally, F-15 Automatic Test Equipment (ATE) has been complex to maintain due to the amount of custom design circuitry in both the ATE and ITAs. This design approach has been used in legacy F-15 support systems, as well as recently fielded equipment. Custom designs have been used to provide unique testing capabilities not readily available in COTS instruments or to satisfy test requirements that were not accounted for in the ATE design.

More recently, the USAF has expressed a desire to migrate towards an open systems architecture using COTS instruments where possible, and non-active ITAs to overcome the obsolescence and long-term sustainment issues associated with complex custom designs.

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National Center for Manufacturing Sciences (NCMS), to perform the Synthetic Instrumentation Commercial Technologies for Maintenance Actives (CTMA) program. The focus of the SI CTMA program is to upgrade an existing F-15 support system design to incorporate emerging Synthetic Instrumentation technologies and to demonstrate the capability to meet the current and future support needs for the F-15 aircraft, as well as applications within the broader DOD community.

The main objectives of this program are to develop and demonstrate, in an operational environment, leading edge test technologies that can have a revolutionary impact on the type of automatic test equipment that is in place, over extended service, to maintain operational readiness levels associated with frontline combat aircraft units

The F-15 ATE target for this technology insertion is based on a Teradyne Spectrum 9100 Core ATE, with extensive tailoring by Boeing to satisfy F-15K avionics test requirements.

The Spectrum 9100 ATS is an open system, with non-proprietary hardware and software architecture that can be configured as needed to support avionics testing.

The Test Station

The station controller is a COTS based PC, using Windows 2000 operating system.

This existing F-15K system currently performs intermediate level testing on 20 of the latest generation avionics Line Replaceable Units (LRUs) for the Korean F-15 program, and is scheduled for delivery in Sept 05.

This ATE design is extremely adaptable and can be configured to support a wide variety of testing requirements as will be discussed in this paper.

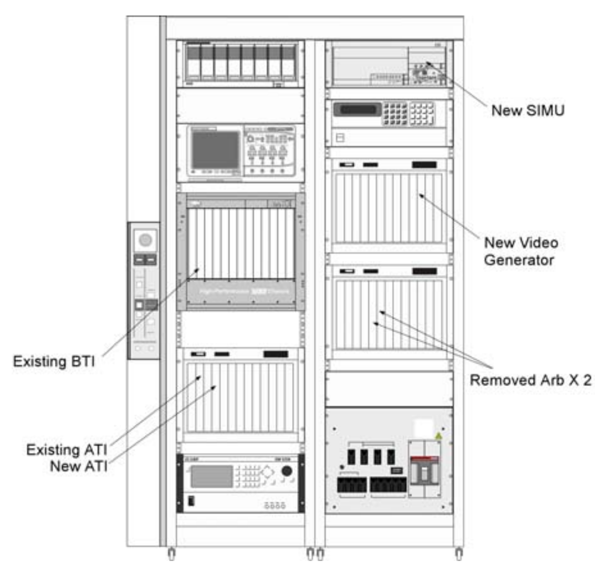
HARDWARE

Synthetic Instrumentation Elements

The synthetic instruments selected for use in this upgrade include the Teradyne Analog Test Instrument (ATI), Bus Test Instrument (BTI), Synthetic Instrument Measurement Unit (SIMU) and a programmable video generator and analyzer.

The BTI (which was already integrated into the existing station) is used for common RS type bus simulation, such as RS232, RS422 and RS485.

The core F-15K station design includes one 32-channel parallel ATI. This asset is currently used to provide traditional instrument functions (function generator, digitizer, limit detector) and to trigger other devices in the station. Additionally, several non-standard busses, not readily supported by the BTI, are being simulated using the ATI.



Station Modification

Synthetic Instrumentation Usage

In an effort to maximize use of the SI resources incorporated into the ATE design, traditional instrument usage was reviewed.

Evaluation of tester assets and avionics requirements were compared to the capabilities of the ATI. Based on the evaluation, several instruments were eliminated from the F-15K Test Station design; the phase angle voltmeter and arbitrary waveform generator. The remaining undedicated ATI channels were then routed to the ITA Interface, allowing access for use by the TPS developer.

A SIMU is being integrated into the station, with the intent of replacing the current digital multimeter (DMM) and counter-timer instruments.

An adapter was created to allow the SIMU and ATI to interface with the existing cabling in the station. This allows the TPS developers to switch between the existing assets and the new SI functions, while the new instrument libraries are being developed.

Additional F-15K ATE traditional instruments, such as Synchro/Resolvers and Linear Variable Differential Transformers (LVDTs) are being evaluated for replacement using SI.

The BTI is targeted as a possible interface for non-standard serial bus.

Since some of the LRUs being demonstrated on this upgraded ATE require several types of video stimulus, a COTS VXI based video generator and analyzer was incorporated into the station. This asset can simultaneously generate the multiple video signals in the formats required for testing the applicable LRUs.

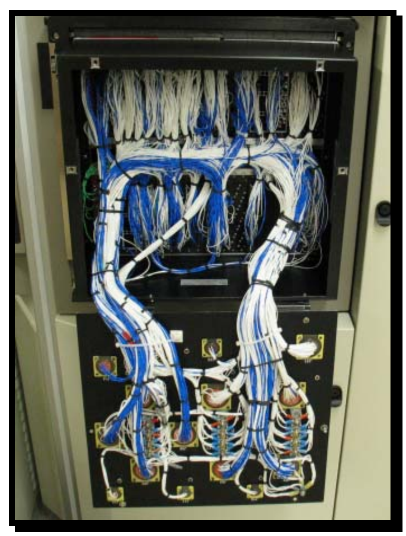
Interface Test Adapter Designs

Performing analysis of the LRU test requirements and integrating the necessary stimulus and response resources directly into the test station, drastically reduces the ITA design effort. All of the TPS ITAs currently in use on both the F-15K Test Station and this project, consist of passive (wire only) design. This approach eliminates the need for custom circuit design, prototyping, debugging and fabrication, thus reducing TPS design and integration effort.

Typical Interface Test Adapter

The addition of the SI components to the ATE will reduce exposure to obsolescence. As new avionics testing requirements are defined, the TPS designer will have increased control over the inherent adaptability of SI hardware, thru the use of software for future requirements.

Using COTS ITA enclosures also reduces fabrication time for the ITAs by eliminating the detail drawings and metal work required.



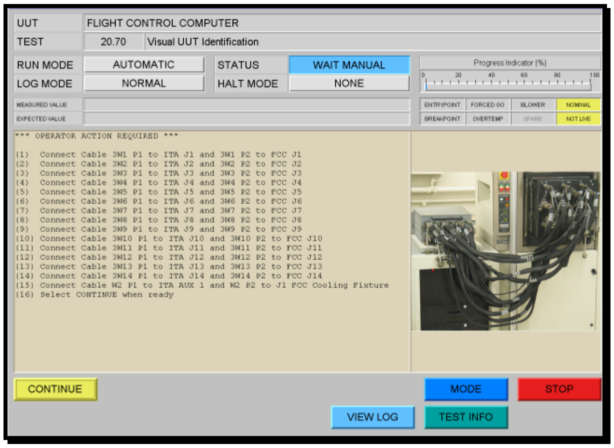
Interface Test Adapter Internal View

On the average, each ITA contains approximately 2000 wires and is designed to support multiple F-15 avionics LRUs.

SOFTWARE

Test Executive

A Boeing developed test executive is used to control the test flow and monitor the test station assets for failures during testing. The test executive also helps to ensure a consistent user interface for each test program.



Typical Test Program LRU Setup Instructions

The test executive also has predefined areas for use by the LRU test programs to display TPS setup/teardown instructions and diagrams, to illustrate adjustments, LRU circuit card assembly (CCA) removals, etc.

Rapid Test Program Development

The LRU test programs were created and modified by entering data into a tabular format. Each table contains test information such as test setups, expected test results, tolerances, and failure actions. These tables are in easy to understand format and require no programming language expertise to understand or update.

Using this software approach, the USAF maintainers require less training to operate or support the ATE than is required for legacy F-15 support test stations.

Converter programs were also employed to translate from existing test programs or electronic formatted Test Requirement Documents to a tabular format. This transferred the basic test flow/strategy framework to be used as a starting point for the new test program.

This process enables the TPS developer to create the test programs in a reduced amount of time, simply by entering library calls into the table locations.

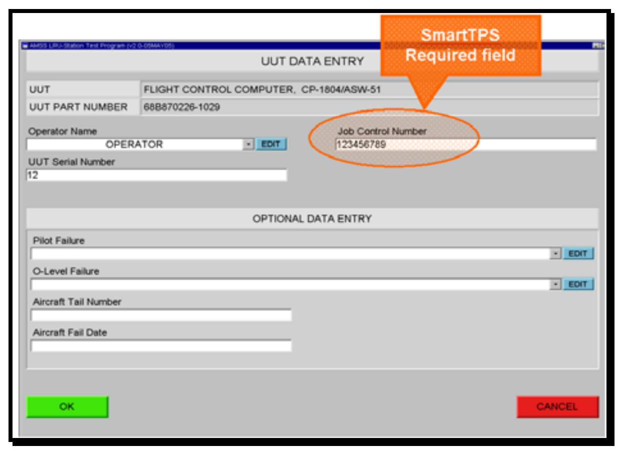
This approach has been utilized on previous programs and facilitates migration to an ATML environment, due to strict formatting of test program information.

Intelligent Diagnostics

The test executive has been updated to incorporate data transferal to and from Smart TPS. These modifications allow the Smart TPS recommendations to be seamlessly displayed to the operator, and entered into the TPS log file. The use of Smart TPS is transparent to the test programs and is selectable by the operator.

The Smart TPS implementation scenario for this project is as follows:

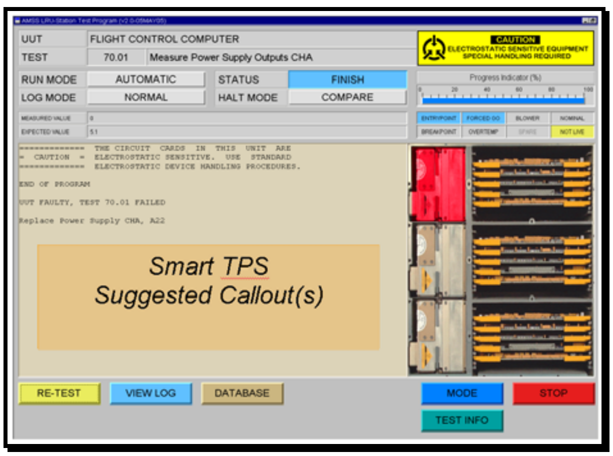
The aircraft system diagnostics data is automatically downloaded to the Smart TPS system from the Computerized Fault Reporting System (CFRS) debriefing tool, using the Air Force Base network between the I-Level repair facility and the flight-line.



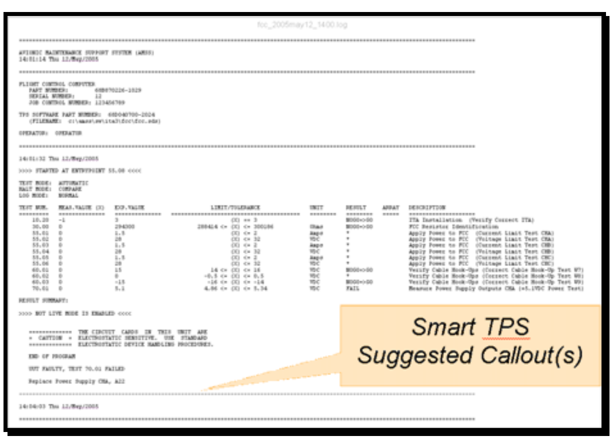
Data Collection Screen

After the operator selects which UUT test program to execute, a data collection panel is then displayed, requiring the operator to enter the Job Control Number (JCN), Work Center Event (WCE) and UUT serial number. Smart TPS then utilizes this data to generate a “Directed TPS” suggestion by reasoning on both aircraft system diagnostics and historical maintenance data. The test group most likely to detect the fault is then display to the operator at the start of the test program. The operator then has the option to start test execution at the Smart TPS recommended test group or at the normal starting point.

Upon UUT failure, the test executive sends the Automatic Test Markup Language (ATML) compatible Test Results to Smart TPS in Test Results Markup Language (TRML) format. Upon receiving the test results, Smart TPS utilizes "Smart Callout" diagnostic-reasoning methods to suggest the most likely repair action based on historical data. This repair action is then displayed, along with the normal test program replace action, in the message area of the display and is also stored in the test results file.



Replace Action Screen



Test Result File

By directing the operator to the most likely area of failure, and most likely circuit card assemblies based on historical data, test times and callout ambiguity groups will be reduced.

CONCLUSION

During the program, it was demonstrated that the cost and effort of legacy TPS migration could be effectively reduced by leveraging new and existing technologies. The upfront analysis of the avionics LRU test requirements allowed the design of non-active ITAs, coupled with ability to use existing source code, decreased the development time of TPSs.

Based on TPSs currently being developed, test times are >50% less than legacy F-15 support platforms.

The use of emerging synthetic instruments can easily be incorporated into an existing platform, reducing parts obsolescence and minimizing impact to support future LRU support requirements.

The utilization of ATML open architecture data transfer, test information is easy transferred to Smart TPS system for use in smart callout procedure.

The potential long-term benefits to the USAF and DoD as a whole are very attractive, particularly when considering the ongoing evolution of synthetic instruments.