Abstract—The manufacturing and test of avionics products for military and commercial aircraft presents a unique set of requirements and challenges. Historically, the development and deployment of production test systems for avionics products such as aircraft data acquisition and recording systems, navigation and communication products, and aircraft network systems have been addressed on a product specific basis—resulting in a variety of test platforms and solutions with little test system commonality and technology. Additionally, this lack of test system commonality and the requirement to maintain legacy products with long product life cycles results in increased maintenance and logistics costs for manufacturing and support test. Consequently, the adoption of a common test platform can offer producers of avionics products lower test costs, improved test resource utilization, and the flexibility to support both new and legacy products. This paper reviews the requirements and the implementation of a common test platform and environment that offers a high level of efficiency, supports the implementation of routine test processes, offers reusability, and allows the consolidation of test resources to facilitate the collection of reliability data and test results.

Keywords—avionics test; production test; functional test

I. BACKGROUND / INTRODUCTION

Manufacturers of avionics products are constantly challenged to develop, manufacture, and maintain/service a diverse range of avionics products, including aircraft data acquisition and recording systems, navigation/communication solutions, and aircraft network systems. These types of products, which are deployed on virtually all commercial aircraft in operation today, require rigorous functional testing as well as a robust test data collection system to ensure overall system reliability and traceability. Additionally, the long product life cycles for avionics products (typically more than 20 years for service and support) requires that the associated test systems be maintained and supported which can be both technically and financially challenging.

Like many manufacturers of high-value, complex electronics assemblies, functional test for avionics products has generally been addressed on a case by case basis with the test strategy and associated test platform usually starting with a clean sheet of paper and with limited consideration given to how one might leverage the design/resources of a current test platform. This approach to test can also be reinforced if there are multiple product lines within a company where each test engineer may dictate both the test approach and technology employed (hardware and software) for a specific product line. The result is a collection of diverse test platforms and systems which may have (very) little in common—from both a hardware and software standpoint—even if the type of hardware and software is very similar if not identical between products. Moreover, due to the diverse nature of the existing test equipment, the networking of test systems can be very difficult, limiting the ability to centralize test program distribution as well as centrally collect test results for FRACAS (Failure Reporting and Corrective Action System) and reliability engineering.

Below are three specific examples of avionics units developed by Teledyne Controls which are supported with unique test platforms (Figure 1):

1. The Flight Data Interface and Management Unit (FDIMU) is deployed on most Airbus commercial aircraft which performs flight data acquisition and aircraft condition monitoring functions.

2. The Wireless Quick Access Recorder (WQAR), certified for use on most commercial aircraft, performs data recording and the wireless transfer of recording data to ground stations using a cellular network.

3. The Aircraft LAN System (AirLAN), is a WiFi and cellular wireless network which also supports an ARINC 429 interface and an Ethernet enabled airborne LAN unit.

Figure 1: Teledyne Control Avionics Products
These products have been developed for different purposes/functions yet all share the same type of external interfaces such as ARINC 429 bus connections.

The lack of test system commonality and the requirement to maintain legacy products can lead to increased maintenance and logistics costs when supporting a diverse collection of test systems particularly when one includes the costs of keeping technicians trained to support these systems. These costs, coupled with the need to centralize test program distribution as well as construct a centralized data collection system for FRACAS and reliability engineering are the primary drivers for developing and deploying a consolidated test platform that can address a wide range of avionics products.

Given the high mix, low volume production requirements for products; it becomes essential that a common test platform be identified that can support multiple products – resulting in decreased test development and deployment time. Additionally, by properly scoping the test requirements for both current and future avionics products, it is anticipated that a common or consolidated test platform will offer lower test costs, better utilization of test system assets, and more flexibility for supporting a wide variety of avionics products – for both manufacturing and service/support test applications.

II. THE REQUIREMENTS

In order to fully address the test needs for a common test platform, an inventory of test requirements needs to be compiled that addresses the needs for all avionics assemblies currently in production or scheduled for production. The requirements also define a modern test environment that can provide a high level of efficiency, support the implementation of routine processes, offer reusability, and allow the consolidation of test resources to collect reliable data and results. Virtually all roles within an Engineering and Production organization need to provide their inputs for such requirements to ensure that a comprehensive set of requirements has been defined.

A. Product Test System Requirements

A review of functional test needs for substantially all of the products in production or scheduled production resulted in the identification of the following resources to support functional testing of avionics products:

- Modular architecture which can be upgraded / changed based on changing / evolving product requirements
- DMM – 6½ digit digital multimeter for DC and AC voltage, current and 2-wire/4wire resistance measurements including support for self-calibration
- High voltage programmable DC source - Discrete output source with three (3) programmable, 14-bit resolution, voltage rails and covering a range from -10VDC to +32VDC. These outputs provide the ability to control discrete avionics inputs to UUTs.
- ARINC429 – avionics control bus interface for support of multiple transmit / receive channels plus the ability to generate representative data for transmission to the UUT as well as interpret data received by the UUT
- Multi-function relay card – Five 10 amp, single pole form A relays; four 2 amp, single pole form A relays; four 2 amp, single pole form C relays; and a configurable relay matrix for routing / distributing test resources and power distribution to / from the UUT
- Switching matrix – a high-density switch matrix supporting a configurable, programmable 192 differential or 384 single-ended channels with common buses and built in self test
- Embedded, system controller – The embedded controller minimizes system footprint by eliminating the need for a desk top controller. Additionally, the Windows based controller supports all modern, standardized interfaces to the test instrumentation
- Thermocouple input module – supports thermocouple temperature measurements for use during environmental stress screening (ESS) of the UUT
- Oscilloscope/Digitizer card – Dual channel oscilloscope or high-speed digitizer which supports simultaneous sampling of UUT analog data with 8-bits of resolution
- UUT interface – Via interchangeable test adapters (ITAs), a variety of UUT form factors and interface connectors can be easily connected / interfaced to the test system
- Support for serial interfaces such as UARTs and communication interfaces such as RS-232
- Support for Ethernet interfaces including Ethernet switches

The configuration detailed above supports the testing of practically all units which are currently in production (one of the main system requirements for a common test platform).

B. Test System Environment Requirements

As noted previously, the development and deployment of a modern test environment encompasses a variety of needs and requirements. Besides supporting the control and monitoring of the test system’s resources, the software test environment needs to support the following requirements / capabilities:

- Open architecture for supporting a variety of T&M control interfaces, including PXI, IEEE, USB, ARINC 717 / 429, Ethernet, etc
- Test development environment that supports interfacing to a variety of application development environments, including textual and graphical based languages
- Structured software architecture that includes a test execution and standardized framework that promotes quick development and reuse of test code
• High level of reusability for predefined test procedures/sequences
• Minimal programming skills required for test development
• Integrated tool set for easily creating UIs for applications
• Ability to manage different classes of users and assign different privileges to users based on their level of training and responsibilities
• Integral data logging facilities – simplifying the data collection and interfacing to a central data collection facility
• Ability to manage the archiving and configuration of multiple test programs – ensuring program integrity

III. IMPLEMENTING A COMMON CORE PLATFORM FOR AVIONICS PRODUCTION TEST

Based on the requirements detailed above, it was decided to adopt the PXI platform as the core component for the new common test platform. PXI, which is a card modular platform, offers a broad variety of instrumentation and provides test engineers with the flexibility to build and easily reconfigure compact, small foot print, test systems. And when combined with an integrated, high performance, embedded controller as part of the PXI platform, the test system provides all instrument control and data processing without having to incorporate a desktop PC. Additionally, this approach allowed all test equipment to be self-contained within a single 14U cart, which allows rack mounting of all components including the UUT ITA, (See Figure 2 below).

When selecting the core PXI chassis, the 6U, 3U, and 3U/6U combo chassis configurations were all considered. Ultimately, the combo chassis configuration (see figure 2) was chosen since it offers the flexibility to incorporate both PXI and cPCI 3U and 6U instruments and still only requires 4U of rack space. Additionally, for avionics applications, many specialized communication bus interface cards that support the ARINC 429 and MIL-STD 1553 busses are typically available in the 6U form factor as cPCI devices, which makes the selection of a combo PXI chassis even more compelling.

Other key components of the platform include switching, analog measurement, user power and the ability to exercise multiple channels concurrently. The test system’s resources were designed to address a wide range of UUTs, including:
• Digital Flight data acquisition/management units
• Wireless / Quick Access Recorders (WQAR/QAR)
• Nav-Com systems
• Network File Servers
• Network router systems

To interface to these various UUTs, a test system interface or receiver (see figure 2) was developed which provides the interface between the test system and the various UUTs. The result is a common interface which can be used to support a variety of UUTs.

With the design and architecture of the test platform hardware finalized, attention turned to selecting and implementing a software test and development environment. Based on the requirements detailed above, it was essential that a test environment be selected that could offer the functionality and features of both a test executive and a test language. The test executive satisfied all of the “non-test” requirements such as data logging, archiving / management of programs, and management of users while the test language offered a development environment which is T&M centric – simplifying program development and deployment. Additionally, with the open architecture of the test development environment, incorporating various instrument control interfaces such as PXI and GPIB were easily accommodated. Using a commercial off-the-shelf software package (ATEasy) allowed the development of a standardized test software system, and provided the ability to reuse measurement routines and procedures without modification - facilitating the development and deployment of new tests.

IV. SUMMARY

Previous generations of test stations would have taken years to develop, but by selecting a commercial off the shelf (COTS) platform as the core component, it was possible to complete the system design in a few months. And as a result, the construction of nine test stations was completed in approximately one year.

Additionally, by standardizing on an integrated test executive and test development software platform, the development and deployment of multiple test solutions was accomplished in a relatively short period of time – realizing a significant increase in test program development productivity. Currently four products are supported with the new platform.
Two new products are hosted on the test system and two existing products have been re-hosted on the new system which were previously tested on aging test systems. The migration of other existing products to this new platform is planned in the near future.

Our experience with defining, developing and deploying a common test platform has shown that significant savings can be realized. By adopting such a strategy, lower development and test maintenance costs can be realized and with a modern, full-featured software environment, accessing and managing test program data is greatly improved.