AVIONICS magazine TECH REPORT

Testing Technology for the Validation and Integration of Avionics Systems

What testing equipment is required for the development of today's highly technical avionics systems? Modularity and COTS is important to provide flexibility, growth potential and efficiency.

Access Intelligence

More and more the development of avionics systems requires extensive testing. New generation aircraft, such as the Boeing 7E7 and Airbus A380, are to be fitted with specialized systems that depend on input/output (I/O) devices to control and monitor various physical processes. Such systems often must share data with other avionics, using multiple heterogeneous communications links.

Avionics Testing Process

Developing today's avionics is a multifaceted process that is made up of numerous development cycles, effecting both hardware and software. Each cycle adds a new set of features to the unit under test (UUT). And each feature has to be validated through module and system tests, to identify design and implementation errors as soon in the cycle as possible. As an avionics system advances in its development certain features may be simulated before being implemented, to enable system and integration tests.

These are the requirements that test methodology must follow. Early tests must simulate system interfaces, while later tests must employ hardware and software interconnections to assure the system performs as expected. Detecting errors in the early development stage can cumulatively save time and money. While modular testing can be performed during a system's development, more comprehensive system and integration testing must be executed with the real target hardware.

Legacy test systems largely have been built "from scratch," then modified and redesigned as a system's development progresses. They address some testing needs but typically share the following disadvantages:

- ➤ High cost/benefit ratio,
- ➤ Can conceal problems by reusing in-flight system architectures for testing purposes,
- ➤ Can hide costs in maintenance and personal training,
- ➤ Provide limited flexibility, leading to limited test system reuse, and
- ➤ Involve late testing cycles, missing regression test capabilities.

Many times, with legacy test equipment, test tasks can be missing—for example, fault insertion at the hardware and software level.

Advanced test equipment design—made highly flexible, with a well-designed driver model—can shorten the interval between UUT development and integration, and thus save money. The design must be able to allow for building the test and integration rig in parallel with the UUT's development. In other words, modern testing technology must be able to easily grow with, and swiftly adapt to, specifications that are subject to change.

A large number of commercial off-the-shelf (COTS) components should be integrated to operate within the test system. These include the standard aircraft communications models, such as avionics full duplex switched Ethernet (AFDX), ARINC 429 and 717, Mil-Std-1553, controller-area network (CAN), serial RS232 and RS422, transmission control or user datagram protocols (TCP/UDP), among others. Whether specifications are added, altered or removed, the test rig must be adjusted accordingly, with minimum effort.

Flexible test systems also should be accompanied by a large catalog of low- and high-precision analog and digital hardware, with or without hardware fault detection. For example, the catalog should include TTL, digital, analog-to-digital converter (ADC), digital-to-analog converter (DAC), rotary or linear variable differential transformers (RVDT/LVDT), function generators, among others.

A highly specialized test system can be built, cost-effectively, on top of a generalized test system. However, the generalized test system should include the following features:

- ➤ An I/O system that addresses all typical and atypical avionics hardware, for example, communication buses, digital and analog devices;
- ➤ COTS hardware components, to benefit from the power of the real-time equipment manufacturer markets, as well as the longevity and availability of products, which play an essential role in obsolescence management;
- ➤ High flexibility in signal wiring;
- ➤ Unified access to online data;
- ➤ A scalable real-time processing engine that is able to run I/O and test simulations in a predictable manner;
- ➤ Data visualization;
- ➤ Standard online and offline analysis tools;
- ➤ User-definable visualization components (panels); and
- ➤ Data exchange interface.

An effective test system should have online and offline visualization tools that provide powerful views to real-time and recorded data. The data may be analyzed using internal or external tools, then modified, preprocessed and reimported to the test system for data replay. User panels may be defined in a panel builder to visualize and change online data, using various kinds of graphical objects.

By incorporating COTS technology with a modular design test system, companies developing new avionics can save both time and money, as well as deliver considerable flexibility.

About Tech S.A.T

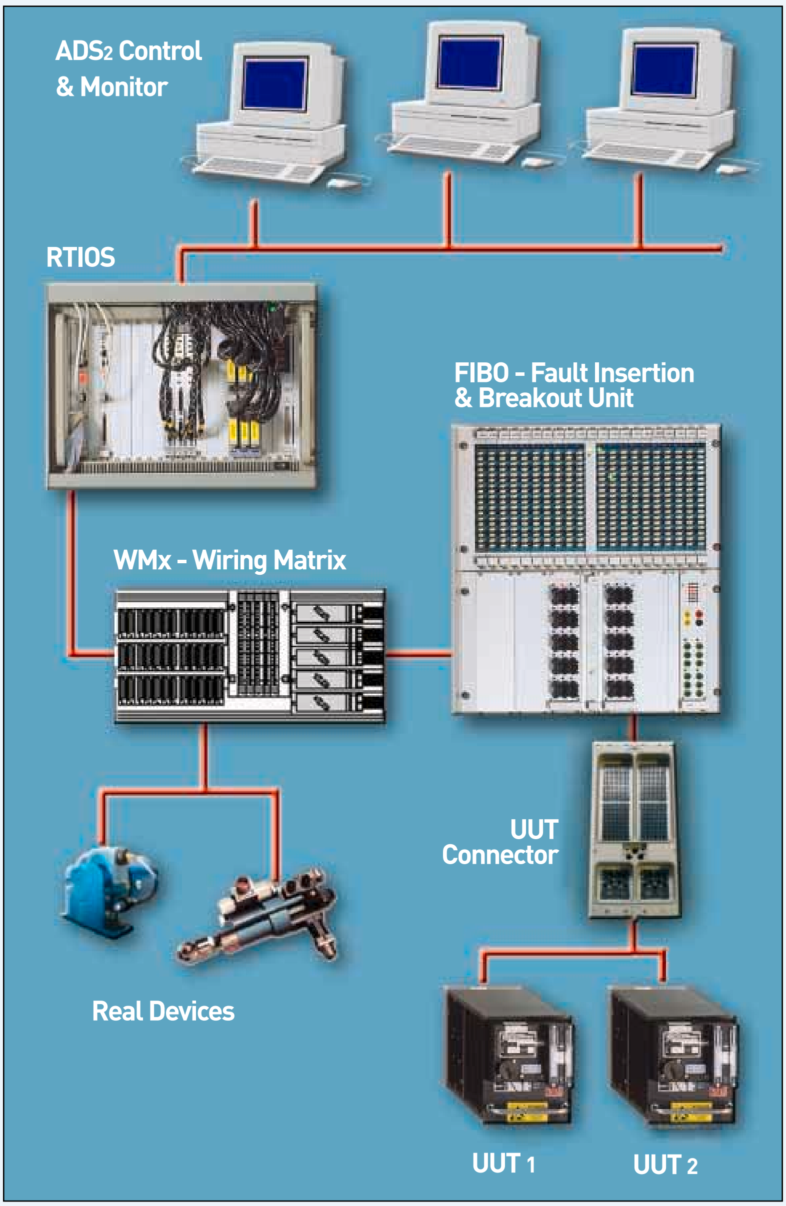
Tech S.A.T GmbH, near Munich, designs and produces customer-specific real-time test and simulation benches for the development and integration of avionics control systems, as well as for maintenance and end-testing. Over the past 15 years it has worked with such companies as Airbus, Boeing, Rockwell Collins, Parker, MTU, Diehl Avionik, BMW Rolls Royce and Honeywell.

Tech S.A.T entered the automated testing field in the early 1990s with its ATLAS-based test rigs used on A320 avionics controller systems. At about the same time Boeing contracted Tech S.A.T and /dev Software GmbH to develop a real-time bus analyzer and recording tool (BART), used as an ARINC 629 and 429 data bus tester during the integration of B777 systems. The ATLAS-based rig and BART evolved into the company's ADS2-SIB system integration bench, which has been completely overhauled to enhance its flexibility and functionality. Today Airbus Germany and several supplier companies employ some 50 ADS-SIBs to integrate and validate A380 avionics systems.

A COTS Made-to-Measure Test Suite

An example of a modular test system with considerable commercial off-the-shelf (COTS) components is the ADS2-SIB (Avionics Development System 2nd Generation-System Integration Bench) produced by Tech S.A.T GmbH and /dev Software GmbH, both based in Germany. Current ADS2-SIB systems use COTS components either as PC-related I/O (RS232, Ethernet), peripheral component interconnect (PCI) devices (either PC or PMC), or mainly VMEbus devices. Execution hosts for the test system are Motorola MPUs running VxWorks or PCs running Windows or Linux. Execution hosts can be connected either via Ethernet, VMEbus or reflective memory interconnections. Individually running ADS2-SIB systems can transfer information via Ethernet to form test clusters. The ADS2-SIB system components include:

- Real-time processing and I/O unit (RTIOS), which holds the system's real-time database and controls the real-time I/O.
- Wiring matrix (WMx), which gives the system integration bench (SIB) the capability to relate all forms of wiring, from the test system's I/O channels to the unit under test (UUT).
- Signal conditioning unit (SCU), which is designed as a modular plug-in card system mounted in a 3U or 6U card cage, or combination of both. The SCU, used for signal adjustment, can also accommodate sensor and actuator simulations or their real counterparts, if needed by the UUT. The real devices also are connected to the wiring matrix.
- Switch unit, which is part of the WMx and is used if the SIB contains both simulated and real devices. It switches the WMx from device simulation to real device operation, and vice versa.
- And the fault insertion and breakout (FIBO) unit, which is optional. The FIBO is used for error injection, monitoring and self-test purposes of avionics test and simulation systems that require both manual and automatic access to each signal line connecting the test system with the UUT. It offers both a modular breakout panel and software-controlled error injection functions, which include signal line interruption, transfer resistance, resistance to ground, short circuit to ground, resistance between two signal lines, and short circuit between two signal lines. The FIBO supports standard signals (DC 35 volts/2 amps or AC 125 volts/0.5 amp) and power signals (up to AC/DC 250 volts/8 amps), and it provides connections to the external measurement and stimulation devices, such as digital multimeter (DMM), frequency generator or oscilloscope.



With the ADS2-SIB, logical system components can be loaded either to hardware or software units. With hardware units they connect an implemented subsystem on the UUT to the test system. With software units, the logical systems components execute a user simulation code to replace a missing feature of the UUT. Software simulations may be hard real-time components, user-written C-code or code built from C-code generating tools, such as MATLAB or MATRIXx. User-defined scripts in /devScript, Python or TCL run in soft real-time environments.

ADS2-SIB

Avionics Development System Integration Bench

AFDX
CAN
Serial
Analog/Digital
Ethernet
ARINC 429
MIL-STD-1553
ARINC 717
Synchro/Resolver
LVDT/RVDT
GPIB
IRIG-B/GPS

»A made-to-measure suit off the shelf«

- Real-Time Simulation
- Hardware-in-the-Loop
- Virtual Prototyping
- Integration Test
- Data Acquisition & Analysis
- Fault Insertion & Breakout
- Signal Conditioning
- Virtual and/or Real Devices
- Interfaces to External Tools
- Interfaces to 3rd-Party Systems:
  - MATLAB/Simulink
  - Statemate
  - MATRIXx

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Tech S.A.T GmbH | Tel +49 (0)8121/703-0 | Fax +49 (0)8121/703-177 | info@techsat.com | www.techsat.com
American Tech S.A.T | Tel +(001)800/887/5851 | Fax +(001)206/374/2538 | sales@americantechsat.com