Testing MIL-STD-1553

After nearly a generation, there are still misconceptions on validating the 1553 databus. An expert draws from his experience to describe the perils and how to avoid then.

by Leroy Earhart*

The most popular serial databus in military avionics today is MIL-STD- 1553. Since 1973, it has become the choice for system integration because of flexibility, inexpensiveness and off-the-shelf availability. Today, it's not only used in military applications, but in commercial systems as well.

1553 is a mature standard for future applications as well as retrofits. Its flexibility enables it to mesh with other standards and network architectures such as MIL-STD-1760A, which defines aircraft stores. The fiber optic version (MIL-STD-1773) and High Speed Data Bus will supplement 1553, but will not replace it. They will not threaten 1553 because they lack its maturity, and other benefits. Economics is a controlling factor and, with military programs being cutback, a drive to modify many interfaces with a higher speed bus may not be feasible.

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Retrofitting applications should continue to grow, as in the new avionics on the B-52, F-15 and F-16. 1553 should continue to broaden its application and probably increase in areas such as flight control. Next-generation aircraft with dedicated avionics that require higher throughput, such as the Advanced Tactical Fighter, will use 1553.

Although 1553 has been around for nearly 20 years, there are sill many misconceptions about its test and validation. Let's consider several areas that appear to me particularly troublesome.

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The purpose of validation testing is to verify compliance of a terminal's databus interface with MIL-STD-1553. Using published test plans, you can verify, characterize a terminal and define its margins and limitations. The information gained is essential to avoid incompatibilities before system integration. Since validation testing does not test the operation or functional aspects of a subsystem, it can be performed as soon as remote terminal hardware is available. Subcontractors who believe that validation testing is too costly and unnecessary could find out how expensive the delay can be.

Our activity in validation testing over the last three years has given us interesting glimpses into the priority some companies put on testing. Some take the time to train personnel and acquire test equipment – while others attempt to ad-lib through the testing process. Most companies fall somewhere in the middle. They generally have test equipment with partial capability, but lack experience for effective testing. It creates a two-fold problem. First, the full capability of a terminal's design will not be determined without extensive testing. Secondly, improper operation not found prior to a production run or system integration becomes far more costly to track down in the long run.

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Two other factors appear to be responsible for insufficient testing. An obvious one is that testing is frequently cut back when costs increase and time runs short. The second reason is that there are widely held misconceptions about the need for testing. Let's look at the three

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most common fallacies, then at remote terminal (RT) failures we have found in testing. Finally, we'll examine several options available for validation testing.

The first misconception is: *"Validation testing is not necessary if validated components are used to build the RT.* "This is the most widely held false assumption we have come across. There are chipsets and components which have partial validation testing by the Systems Electronic Analysis Facility (SEAFAC) at Wright Patterson Air Force Base. Those which SEAFAC found to be satisfactory were "validated" or "SEAFAC certified." While using such parts in an RT minimizes problems, they do not eliminate the need for thorough testing. It is important that the correct validated components be used *together.* This seems quite obvious, but we have tested RTs that had, for instance, the wrong transceivers or transformers (i.e., incorrect turns ratio or quiescent state).

A validated component must also be used correctly. One company, after its first production run, brought us a unit with an eight-layer board – and discovered how costly it was to have the wrong taps on transformer connections.

There can still be problems if the *right* parts are used correctly. Consider, for example, physical location. The proximity of components in the layout can have an effect. Card placement in the LRU (Line Replaceable Unit) also affects performance. Excessive bus cable length can change electrical characteristics and noise rejection. Another problem is that operation of the RT is affected by user software.

Interfacing

The second misconception is: "Be*cause the interface board was validated in one LRU, validation testing isn't necessary on subsequent LRUs. "* Remote terminals using an interface board that passed validation testing should still be tested with at least the electrical and noise rejection tests of the RT Validation Test Plan. One factor that affects performance is placement of the card in the LRU. Different bus cable lengths, variations in proximity to other devices and variations between separate LRUs all have an effect. Different power supplies can influence board performance. Although these physical variations mainly affect electrical and noise rejection, it should not be taken for granted that protocol tests will produce identical results with different software or firmware.

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Past Operation

The last misconception is: *"Validation testing is not necessary because the LRU has been operating in the system."* The fact that an RT is already functioning (i.e., it's flying) does not mean it satisfies MIL-STD-1553. We once evaluated an RT that had been flying and found a broken address line - among other problems. The standard has built-in margins and the Test Plan does test for them. Using an RT without required margins in a system reduces operating margins for the entire system. Margins are not checked in normal system operation or operational testing. Normal system operation or operational testing cannot verify proper handling of detected errors or proper noise rejection. Consequently, testing of an integrated RT under actual flight conditions will never be as thorough as validation testing.

We find, in performing RT validation testing, that many RTs have problems with the same tests. One is

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the Zero Crossing Distortion (ZCD) test which fails an RT for detecting errors for a ZCD of 150 ns. Inadequate test equipment is the major culprit. Not all test equipment is created equal and measurement resolution to 2 ns or less is not a standard feature. This is a good example of where accuracy is necessary for characterization of an RT's margins. Another problem is the response time of an RT to a command. We have seen the allowable 12.0 us exceeded many times. We've had several RTs respond incorrectly in protocol tests by setting the Busy bit or Subsystem Flag bit inappropriately. Using the wrong part (transformer/transceiver) or using the right part incorrectly is common. Improper initialization of the chip is also common because everyone writes software differently. In fact, some failures are actually problems in the chipset design that SEAFAC missed in its testing!

Each RT, of course, has its own problem areas. Take, for instance, the output amplitude of one RT that started transmitting at 21.0 V but decreased to 18.5 V by the end of the 33 word message. While this is not a failure, it indicates a potential problem. One blatant error we've had was an RT that transmitted in response to a receive command! Another RT, on power up, began responding, stopped responding - then started responding again. Most problems are not that exotic; improper operation is usually due to misunderstanding the standard or data sheet of the protocol chip. The bottom line is, in three and a half years of validation testing, not one RT passed the RT Validation Test Plan on its first try!

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Verifying that a design meets MILSTD-1553 and that options are performing correctly is an enormous task. To obtain acceptable results it is necessary to have appropriate test equipment and experienced personnel. Two alternatives are available. One is to train personnel who can be committed to validation testing and acquire dedicated equipment so measurements and results are repeatable. If several MIL-STD-1553 projects are in the works, it may be feasible to set up a test facility.

EQUIPMENT FOR 1553 VALIDATION TESTING

1553 Bus Tester	Oscilloscope
1553 Noise Generator	True RMS Voltmeter
Connection Panel	Impedance Analyzer
Host Processor	Function Generator

The Connection Panel provides the equivalent functions of bus couplers, networks, terminators and cables required for test configurations.

The 1553 Bus Tester is a modular test instrument designed for testing and evaluation of MIL-STD-1553 A/B terminals and systems.

The 1553 Noise Generator provides band-limited white Gaussian noise required for noise rejection testing of terminals designed to MIL-STD-1553.

The other alternative is to bring in specialist in MIL-STD-1553 validation testing who can complete testing in a day or two. A specialist a can provide a wealth of experience and a knowledgeable interpretation of the standard. He can assist in solving problems on the spot. As a third party, the specialist may also give more credibility to test results.

Because of the complexity of testing, the Air Force requires Douglas Aircraft Company, prime contractor for the C-17, to evaluate and approve test facilities (equipment, test procedures and reports) before validation testing. Our company, Test Systems, has been approved by the Air Force and Douglas Aircraft Company for C-17 validation testing.

Our experience has shown that neglecting validation testing for an interface as complex as MIL-STD-1553 can be costly. Even when such testing is not contractually required, the supplier must usually satisfy requirements of MIL-STD-1553. The RT Validation Test Plan is the best guideline available and we recommend that it be performed on all 1553 remote terminals before system integration.

1553 Validation Approved

Test Systems announced approval of its MIL-STD-1553 Remote Terminal Validation Testing Service by the Air Force and Douglas Aircraft for the C-17 program. The independent service has also been approved for other programs such as the B-2 Bomber (Northrop) and KC-135/ Speckled Trout (Boeing).

Remote terminals are tested to the RT Validation Test Plan. A test report documents results, and assistance provides in solving problems if there are failures. Test Systems has been performing 1553 validation testing since 1987. Customers include the Air Force and Navy, and several U.S. and Canadian firms.

MIL-STD-1553

TEST EQUIPMENT

1553 BUS TESTER

- Complete error injection/detection for testing 1553AB terminals and systems
- Simulates a Bus Controller, up to 32 Remote Terminals and/or a Bus Monitor
- Designed for all phases of testing: Development, Validation, and Production
- Dynamic/Real-time Simulation with software support library

1553 NOISE GENERATOR CARD

- Band-limited additive white Gaussian noise for Noise Rejection testing
- PC/AT compatible with **software**

1553 INTERFACE CARD

- PC/AT (286, 386 or 486) compatible 1/2 size board with software included
- Operates as Bus Controller, Remote Terminal or Bus Monitor

TRAINING

MIL-STD-1553 2-DAY SEMINAR

- Thorough discussion of MIL-STD-1553 theory, application and testing
- Two hands-on lab sessions on 1553 communication and trouble-shooting
- Offered in Phoenix and available on-site

MIL-STD-1773 SEMINAR

- Fiber optic version of MIL-STD-1553
- Problems and benefits of fiber optic transmission

TESTING SERVICE

REMOTE TERMINAL VALIDATION TESTING

- Air Force approved testing service, test procedure and test report
- Testing to the RT VALIDATION TEST PLAN
- Assistance in analyzing test results and trouble-shooting problems
- Available in Phoenix or on-site

For more information contact:

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Supporting MIL-STD-1553 *since 1979*