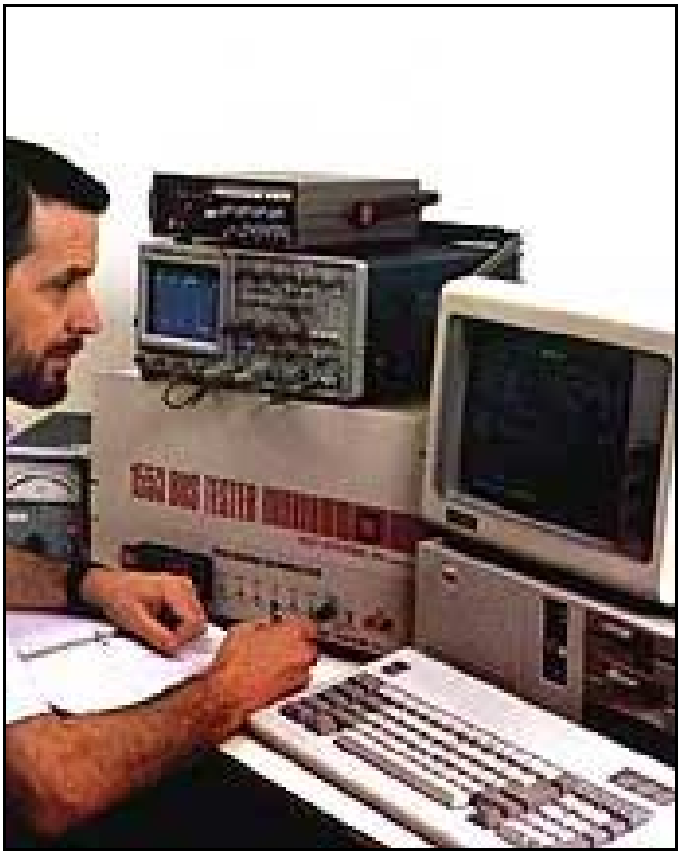
MIL-STD-1553 Validation Testing: Facts and Fallacies

By Leroy Earhart, TEST SYSTEMS, Inc., Phoenix, AZ



Test set-up for MIL-Std-1553 remote terminal validation testing.

The C-17 transport, the B-2 bomber and the KC-135 Speckled Trout are just a few programs that have two things in common: each uses the MIL-STD-1553 data bus to interconnect its avionics and each requires validation testing of its MIL-STD-1553 remote terminals.

The purpose of MIL-STD-1553 validation testing is to verify compliance of a terminal's data bus interface with MIL-STD-1553. Published test plans for MIL-STD-1553 terminals are currently the best tools for verifying compliance, characterizing a terminal and defining its margins and limitations. The information gained from validation testing is essential for minimizing incompatibilities prior to system integration. Since validation testing does not test the operation or functional aspects of the subsystem, it can be performed as soon as the remote terminal hardware is available. Subcontractors who believe that validation testing is too costly and unnecessary are finding out how costly it can be to delay or avoid testing.

Providing a validation testing service for MIL-STD-1553 remote terminals over the last three years has given the industry interesting glimpses of the priority companies put on testing. Some companies have taken time to train their personnel and acquire appropriate test equipment, while other companies have tried to ad-lib their way through the testing process. Most companies fall somewhere in the middle. They may have test equipment with partial capability but lack the experience in testing necessary for maximum effectiveness. This results in insufficient testing and creates a twofold problem. First, the capabilities and margins of the terminal's design can not be properly determined without extensive testing. Secondly, any improper or marginal operation not found prior to a production run or system integration can be more costly to track down and correct in the long run.

There are two other factors responsible for the limited testing being performed. The obvious reason is that testing is frequently cut back when costs increase and time runs short. The second reason is that there are widely held misconceptions regarding the necessity for testing.

The first misconception is validation testing is not necessary if validated components are used to build the remote terminal (RT). This is the most widely-held misconception. At present, there are several chipsets and other components which have undergone at least partial validation testing by the Systems Electronic Analysis Facility (SEAFAC) at Wright Patterson Air Force Base. Those components which SEAFAC found to be satisfactory were validated or SEAFAC certified. While using validated or SEAFAC certified parts in a RT minimizes potential problems, it does not eliminate the need for thorough testing. It is important that the correct validated components be used together. This seems obvious, yet different RTs were tested that had, for instance, the wrong transceivers or wrong transformers, i.e., incorrect turns ratio or quiescent state. The validated component must also be used correctly. One company that after its first production run, brought us a unit with an eight-layer board for

testing, found out how costly it was to have the wrong taps on their transformer connected.

There can still be problems even if the right parts are used correctly. Consideration must be given to the physical location of the parts. The proximity of components to one another in the PC board layout can have an effect. Also, card placement in the LRU can affect performance. For example, excessive bus cable length can affect electrical characteristics and noise rejection capability. Another problem to be aware of is that the operation of the RT is affected by user software.

The second misconception is because the interface board is validated in one LRU, it is not necessary to perform validation testing on subsequent LRUs. Remote terminals using an interface board that has 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 will affect performance is the placement of the card in the LRU. Different bus cable lengths, variations in proximity to other cards or devices and other variations between separate LRUs will have an effect. For example, different power supplies can noticeably affect the performance of a board. Although these physical variations will have an effect on the electrical and noise rejection characteristics, it can not be taken for granted that the protocol tests will produce identical results if the board uses different software or firmware.

The last misconception to discuss is validation testing is not necessary because the LRU has already been operating in the system. The fact that an RT is already operating in an application, i.e., it is flying, does not mean that it satisfies the requirements of MIL-STD-1553. The company once tested a RT that had already been flying and found a broken address line, among other problems. The standard has built-in margin and the test plan tests for this margin. Using an RT without the required margin in a system will reduce the operating margin for the entire system. Margins are not checked in normal system operating or operational testing. Normal system operation or operational testing is not capable of verifying either proper handling of detected errors or proper noise rejection. Cons; Consequently, testing of an integrated RT under actual operating conditions will never be as thorough as validation testing.

In performing RT validation testing, it is found that many RTs exhibit problems with the same tests. One of these is 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 here. Not all test equipment is created equal and measurement resolution to 2 ns or less is not a standard feature. This is an example of where accuracy is necessary for proper characterization of an RT's margins. Another problem is the response time of an RT to a command. The allowable 12.0 us has been exceeded many times. Several RTs have also responded 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 his own software differently. In fact, some of the usual failures are actually problems in the chipset design that SEAFAC missed in their testing.

Of course, each RT has its own problem areas. Take for instance, the output amplitude of one RT that started transmitting at 21.0 V but had decreased to 18.5 V by the end of the 33 word message. While this is not a failure, it does indicate marginal operation or a potential problem. One of the more blatant errors that has been found in testing was an RT that transmitted data in response to a receive command. Another RT, on power up, started responding, then stopped responding and then started responding again. Most problems are not that exotic; improper operation is usually due to a misunderstanding of the standard or the data sheet of the protocol chip. The bottom line is that, in 3-1/2 years of validation testing, not one RT passed the RT validation test plan on its first try.

Verifying that the RT design meets MIL-STD-1553 specifications and that all implemented options are performing correctly is an enormous task. To obtain acceptable results in validation testing, it is necessary to have appropriate test equipment and personnel experienced in MIL-STD-1553 testing. Two alternatives are available. One option is to train personnel who can be committed to validation testing and acquire equipment that can be dedicated so that 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. The other alternative is to bring in a specialist in MIL-STD-1553 validation testing who can complete testing in a day or two. A specialist 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 credibility to the test results.

Experience in testing has shown that neglecting validation testing for an interface as complex as MIL-STD-1553 can be a costly mistake. The more testing that is performed, the more the need for validation testing is confirmed. Even when validation testing is not contractually required, the supplier is generally required to satisfy the requirements of MIL-STD-1553. The RT validation test plan is a tool for determining a remote terminal's compliance with the standard. It is recommended that complete testing, according to the RT Validation Test Plan, be performed on all MIL-STD-1553 remote terminals prior to system integration.

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