

CAN AVIONIC TESTABILITY REQUIREMENTS BE ENFORCED?

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Theoretically avionic testability can be specified, levied contractually, designed and integrated into hardware, and demonstrated. The intent of this paper is not to identify how we can achieve testability but how we can hope to get the maximum testability that is practical by a methodology of enforcement and control from the time the avionics procurement is envisioned through the design, development, and acceptance. The review and concurrence in testability is accomplished through the data submittals from the avionics supplier. Enforcement is directly related to the type of data required, when it is required, the formats specified, and our ability to get exactly what was contractually required. The optimum method of achieving this end is to have support engineering personnel participate through the stages of data preparation, review, and resubmittal. The participation is via concurrent reviews in conjunction with the avionics design review cycle, and by directing the contractor to include specific testability requirements for each UUT on a case by case basis.

Background and Introduction

Government and industry have been striving for avionic testability for several years. This paper will reflect some approaches to testability and the methods attempted to enforce testability requirements.

It began back in May of 1968 with the release of AR-8, General Requirements for VAST/Avionics Systems Compatibility and AR-10, General Requirements for Maintainability of Avionics Equipment and Systems. Those documents have been modified, changed, added to, deleted from, and are being reissued as Military Standards for stronger contractual coverage. AR-8 has already been reissued as MIL-STD 2706 (AS) General Requirements for Unit Under Test Compatibility with Automatic Test Equipment and AR-10 will be reissued in the near future. The mere fact that it has taken over a decade for the basic documents, specifying testability in relation to ATE, to evolve serves to illustrate the relative infancy of the concept of testability. Testability in avionics is a joint effort of organizations responsible for avionics design and support equipment. The evolution of the documents has had the effect of elevating testability

requirements to a point where it is identified and considered with the classical avionic design parameters of operational capability, size, weight, power, reliability, maintainability, and cost.

The Military Standards will be the vehicle used to ensure that a reasonable effort to achieve testability in design will be made. As such they are being levied contractually on avionic sub-system and weapon system contracts. However, as with any specification it is subject to interpretation by different individuals and companies. What tends to occur is that each major avionic or weapon system developer rewrites the documents to tailor them to their unique requirements so they fit within their company's policies and procedures.

We now would have a theoretical specification levied contractually, which has been modified by the contractor so that a practical attempt at testability can be made.

However, the subject of this paper is "Can Avionic Testability Requirements Be Enforced", not is it practical. To attain this result it will require exercising discipline over the design activities technical approaches before they are finalized.

There are three (3) key areas where that discipline must be maintained and they have been identified many times over as electrical design, mechanical design, and management objectives. The electrical and mechanical design criteria are well known and have been discussed and analyzed in several publications. Management and its objectives is where testability can come to fruition through enforcement. Enforcement of specification development, data requirements, design review policy, and involvement of the proper personnel are managements responsibility.

The best written specification will go unheeded, your most productive engineer will tend to vacillate, your design reviews will be contractual formalities, your data will be incomplete, inaccurate, and probably late unless management is capable of creating the required discipline in design. Since "discipline is created by enforcement" management must establish an environment where testability is regarded simply as another design factor that must be enforced to achieve cost effective, technically efficient, and timely maintenance.

Specifications and Data

We have the contractual vehicles, the fundamentals of what components to use, what circuitry to employ, how to layout boards, where and how to utilize test points, thus the technical disciplines to achieve testability. We must attempt to identify the optimum methodology to enforce these design factors in the evolution of a new piece of avionics.

The initial requirement to enforce testability is to contract for the right data, prepared in the proper format to facilitate review and change, with the proper content; to be delivered at the appropriate time in the design cycle.

The specifications to accomplish this task must identify, in detail, the data that is required to be developed and presented for review, comment, and update. One data item we must specify is a TRD (Test Requirement Document) that contains UUT testing information independent of any support ATE. It shall be sufficiently definitive that it identifies the explicit test parameters for each performance verification and fault isolation test and contains a complete logic flow diagram. It is strongly felt that the TRD must be contractually specified, not as a data item in a DD 1423, Contractor Data Requirements List, but as a deliverable against a contract line item. That requirement would force the supplier to establish milestones with specific technical objectives and firm delivery dates for the TRD that would coincide with key avionic design milestones. By doing that we would be forcing management to meet milestones which under previous contracts were not visible and therefore not stressed at a high enough level. Managements awareness of the importance of having the TRD prepared concurrently as the avionics is designed cannot be over emphasized. It is the most effective tool to provide test related feedback into the avionic design.

Also the avionics contractor must accept the specifications with the understanding that any proposed deviations or waivers effecting testability will require in-depth justification to the approving authority.

Managements Role

Managements key role in enforcing testability in avionics is establishing effective utilization of personnel. It involves creating an atmosphere of cooperation and understanding within all of the technical and managerial disciplines.

Let's start at the beginning of the avionics design phase. Obviously, the avionic designers must be permitted enough latitude to achieve their operational objectives and other factors required by the avionics design specification. However, it is also at this early stage, paper design, where ATE/support oriented engineers can be most effective. He should be made a part of the design/design review team with the author-

ity, as deemed required by management, to achieve testability. Since some of the effects of achieving testability are, or may be, counter productive to reducing size, weight, or power there must be some definitive objectives defined within the overall project, be it an avionic subsystem or a new weapon system.

In order to get avionics design, reliability, support, maintainability, data, configuration production and test personnel to form an effective team it takes management visibility and control at a level which encompasses all disciplines. For our purposes let us call that level "top management". Thus top management must accept the fact that design for testability is a factor which has equal weight with the other design goals or it has some defined weighting factor. Whatever their decision it must be made clearly and precisely in terms of overall project/program objectives. It must be made blatantly clear to all organizations just how far management is willing to back and enforce their decision so that the practical achievement of testability will be dependent on the capabilities of the responsible engineering personnel.

When top management puts emphasis on testability, as they do on the other major considerations of avionic design, they should realize they are not forsaking their responsibility to build better and more capable equipment. What they are doing is raising one more design objective to a level where everyone involved in design is now aware of it. With managements identification of testability as a design goal they have opened the door so that all design reviews and technical discussions must consider testability. I don't believe any of us are naive enough to think that it will become the driving force in design but if it will create some thought, which in turn raises discussions, which leads to a conclusion, which is then accepted or rejected on its merits when compared to other design tradeoffs then we will begin to achieve and enforce testability to a greater extent.

Top management must realize and understand that the only viable way to enforce any requirement that cannot be measured, tested, and verified independently is with a methodology that is dependent on a subjective analysis. The size, weight, power requirements, operational capabilities, can all be tested and verified prior to the avionic sub-system being sold-off. We can write acceptance test specifications and procedures to accomplish those tasks. However, with testability you cannot test for it until after a support philosophy has been established, a TPS designed and developed on an ATE system, and finally until operational usage establishes valid and definitive failure information. Thus since objective methods are not available at the time we require them, the only course left to us is the subjective approach. That approach must require involvement in the avionic design phase by ATE oriented support engineers who are given the prerogative of raising

testability considerations during the critical phase when the avionics is being defined. That is the method of enforcement that must be advocated by management to attain the degree of testability that is required today as electronic and component technology advances continue at breakneck speeds.

We in the ATE support world must rely on our engineering and management expertise having a part, how large or small dependent on some of the above considerations, in the avionics design from start to finish, and in the generation of our ultimate source data package for TPS development, the testability implemented and documented within the TRD.

Review Cycle

Once management has committed to the effort it now becomes a matter of exactly how to implement the methods, obtaining the right data at the right time, indoctrinating avionic designers in testability with reasonable, astute, intelligent inputs at the opportune time to effect but not impact design.

The avionic reviews commence from the time a procurement package or internal design package is initiated. There are two (2) critical parts of the package, one being the procurement/design specification and the other management requirements. That package must contain the vehicles for making things happen relative to testability.

The procurement specification must be prepared with the intent of defining the degree of testability projected to be built into the box. Space, weight, power, etc., must be considered for BIT circuitry, test points, buffering, noise immunity to isolate the test point, and functional design consistent with the BIT and test points provided. Also, it should avoid such problems as multiple logic families, initialization, interrelated failures, redundant or feed back loops, inappropriate component selection and others, which tend to mask failures, cause ambiguities in test results, lead to longer test times, require sophisticated troubleshooting techniques, and require specially trained personnel to accomplish test and maintenance.

With those elements included in the specification, and managements backing, we can begin to enforce them and feel confident that consideration will be given during design. It then becomes a matter of when, where, and how we begin a series of technical and project decision points made periodically or incrementally as the avionics evolves from concept to hardware.

In order for the avionic design to proceed with minimal impact, the reviews specified and conducted for testability determination should be the identical reviews contractually specified for the avionics. Thus our engineers must be capable of enforcing all technical design goals. The management requirements document must encompass all of management's objectives for the avionics, the ATE,

and the TPS from data requirements through acceptance. From the aspect of achieving testability, the critical enforcement vehicle is direct participation in the avionic design/design review process.

There are several decision points in the avionic design cycle when reviews are held. They vary in title and sequence from contract to contract but for our purposes, we will label them and sequence them as follows:

- a. Concept Review
- b. Initial Design Review
- c. Critical Design Review

Since we are all familiar, in general, with the objectives of these reviews, let us be specific only about what need be considered for enforcing testability. At the concept review what must be ensured is that testability is in fact being considered in the alternative technical approaches being evaluated.

At the initial design review, the alternatives have been reduced into a design which would define testability at the sub-system and UUT levels. That is, the hardware methods for implementing testability have been considered and determined within the size, weight, and power constraints of the avionics. The decisions should be made relative to establishing and satisfying mission objectives, considering preliminary failure predictions, and evaluating design parameter trade-offs.

The critical design review is held to establish the "final" design of the avionics, i.e. it meets contractual specifications. At this point the degree of testability is known precisely since it is or is not included in the hardware. If there is insufficient testability at this time, then in essence it wasn't enforced properly.

Those three reviews are the major decision points but those reviews would be meaningless without the daily and continuous engineer to engineer discussions and disagreements about the minute details of the design. That ultimately is where the enforcement of testability happens. The preparation of avionics source data, schematics, specifications, and the TRD by the avionics designers and their subsequent scrutiny by the support engineer is the single most important element of enforcement. The TRD is the one data element essential for testability analysis. The TRD takes into account the designers knowledge of failure modes and effects, probability of failures, and degraded mode versus catastrophic failures to emphasize and document the significant failures in the circuitry. From that analysis the logical flow of tests necessary to test for those failures is produced. Then the detailed test parameters are documented for each test in the logic diagram. Once the initial TRD is prepared it must be refined, be a required review item at each major design review, with an initial submittal at the

same time avionic production drawings are released. The TRD will continue to evolve throughout the avionic and TPS development cycle and is subject to continuing contractual update and revision until the final document is delivered at the time of TPS acceptance.

Who Enforces Testability?

Who takes the actions presented above? Who can positively effect the decisions? Who must take the responsibility for enforcement? The answer in all instances is that the "customer" must take that role. In some cases that would be a weapon system prime, responsible for the contractor furnished equipment in his aircraft. It could be the government when buying government furnished avionics sub-systems. It also can be a joint government/weapon system contractor effort when circumstances warrant. However, even in a joint effort, the heavier burden falls on the contractor, to protect his vested interest in the aircraft and because the government historically doesn't staff up to the level required for that type of effort.

The customer must be willing and able to devote support engineering manhours during the avionic design phases. This is not easy to sell either in-house or at the procuring activity, which again points out why top managements backing is essential. However, by levying the contractual vehicles which require management control and direct the efforts of the engineering disciplines we will establish the basis of an effective methodology to attain testability. It will not take a large staff of people initially but as the avionics nears design freeze and build, the staff will have had to grow to the level where it is capable of transitioning into the TPS development effort. The staff at this time will have an in-depth knowledge of avionics they must support, the TRD has been under surveillance and review from its inception, and the degree of testability inherent in the avionics is a known quantity which, even if it doesn't meet desired objectives, is defined and documented.

So I believe we can enforce testability in avionics. It isn't simple and it requires initiative and support from all levels of management, and engineering, from within industry and the government. It is expensive to accomplish these tasks but in terms of life cycle costs of the avionics, when the right trade-offs have been made and implemented, it is well worth the price. When the cost of support equipment, both hardware and software, the training, the spares, and the maintenance manhours expended are all included, then every dollar spent in attaining testability will be returned to the program several times over. I will let all the varied and extensive cost models available to us establish the quantitative amounts. However, from the viewpoint of an engineering activity responsible for ensuring support of avionics on automatic test equipment any money saved is an added plus. Because without testability in the avionics of today and the future there

will be no practical, cost effective method to provide the testing and support required. Thus, our goal should be to inform and convince top management in both industry and government that there must be a concerted effort to allow/permit testability in our avionics. Avionic testability can be aimed at several levels of aircraft support. As we move into the 1980's, we may have to look at the aircraft as one huge, complex, bus oriented testable unit. Or we may be able to aim our testability at the avionics sub-system level and attempt to do all our maintenance within the aircraft on a total system level with no other black box testing required. Or we may find that our goals in avionics capability versus the usual trade-offs still require us to test black boxes at intermediate level. Whatever evolves, the one common denominator is that testability must be built into the system or support will be impractical if not impossible.

References

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