



UNITED STATES GENERAL ACCOUNTING OFFICE  
WASHINGTON, D.C. 20548

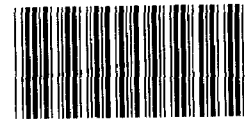
22860  
119274

MISSION ANALYSIS AND  
SYSTEMS ACQUISITION DIVISION

B-208483

AUGUST 6, 1982

The Honorable Caspar W. Weinberger  
The Secretary of Defense



119274

Attention: Director, GAO Affairs

Dear Mr. Secretary:

Subject: Testing and Maintenance of Weapon Systems May Be  
Enhanced by the Design for Testability Concept  
(GAO/MASAD-82-38)

We completed our survey of the use of the design for testability concept in the development and acquisition of major weapon systems. The concept shows significant promise in helping to solve some of the problems in the testing and maintenance of fielded weapon systems, and we fully support these efforts. Properly applying the concept should lead to decreased life-cycle costs and possibly improvements in weapon system reliability and availability. The Department of Defense's (DOD's) experience with previous attempts to solve these problems, however, causes us to urge caution in implementing the concept. To this point, there have been no formal reviews or analyses within DOD to evaluate and quantify its benefits and limitations. Presumably, as the program matures, these matters will receive appropriate attention. We suggest that you monitor this initiative closely to ensure its potential is realized.

The design for testability concept is an evolving but still immature discipline that would require weapon designers to incorporate provisions for improved testing in their designs early in the weapon system acquisition process. The concept relies heavily on built-in-test features and automatic test equipment. It will require designers to evaluate each subsystem or component and add test circuitry or equipment where feasible. The goal is to reduce field testing time, improve diagnostic capabilities, and consequently reduce maintenance time.

EVOLUTION OF THE DESIGN  
FOR TESTABILITY CONCEPT

The design for testability concept is an attempt to solve some of the current problems associated with testing weapon systems after they are deployed. Previous attempts to solve weapon system testing and maintenance problems have had mixed results.

(951678)

003183

Built-in-test features were used in systems designed in the 1960s and 1970s in an effort to determine the operational status of equipment. In many cases, particularly in avionics, the use of built-in-test resulted in high false alarm rates and unneeded maintenance on properly performing equipment. These problems contributed to a reduction in the operational availability and reliability of these systems and increased life-cycle costs.

In our January 29, 1981, report, "Effectiveness of U.S. Forces Can Be Increased Through Increased Weapon System Design" (PSAD-81-17), we pointed out that inadequate test capability can contribute to decreased readiness, maintainability, and reliability. For example, we specified that the automatic test equipment used to support the F-15 contributed to the aircraft's poor readiness. The software used in three different levels of equipment was incompatible, and the built-in-test and avionics intermediate shop equipment was unreliable. Furthermore, we stated that the Army's AH-1 helicopter experienced problems with its TOW missile system because the subsystem used in launching and guiding the missiles achieved only about 100-hours mean time between failure of critical mission-related components. The main cause of these failures was attributed to the poor reliability of various electronic modules and the system's built-in-test equipment.

Because of problems such as these, DOD and industry officials recognized the need to improve weapon system test capability and to use a design approach that would enable maintenance personnel and operators to quickly determine the operational status of equipment and to isolate the cause of the problem. As a solution, DOD in 1978 initiated the design for testability concept.

#### OBJECTIVE, SCOPE, AND METHODOLOGY

Our objective was to evaluate the feasibility of adopting the design for testability concept. Specifically, we obtained and evaluated (1) evidence pertaining to the benefits and limitations of the concept, (2) military service and contractor efforts to develop and implement the concept, and (3) coordination of testability efforts within the individual services. We reviewed and obtained existing documentation and discussed the advantages and disadvantages of the concept with military and contractor officials. We also interviewed officials in the Office of the Secretary of Defense, Joint Logistic Commanders Panel on Automatic Testing, Air Force Systems Command and its Aeronautical Systems Division and Rome Air Development Center, Naval Surface Weapons Center, Air Force Logistics Command and its Acquisition Logistics Division, and Army's Tank-Automotive Command.

JOINT LOGISTIC COMMANDERS  
PANEL AND SERVICE EFFORTS

Joint Logistic Commanders Panel efforts

Under the sponsorship of the Joint Logistic Commanders Panel on Automatic Testing, the services are laying the groundwork to develop and implement the design for testability concept without having determined its benefits and limitations. Design guides for testability as well as new military standards defining its use are being prepared, but no effort is being made to ensure that the benefits of the concept outweigh the cost of implementation.

The Panel is pursuing a \$190 million program consisting of about 77 tasks, of which 13 are directly related to testability. The testability tasks are estimated to cost about \$8 million during fiscal years 1981 through 1985. The Panel serves only as a clearinghouse to coordinate efforts among the services, help reduce duplication of work, and publish and disseminate products that have joint service application. Management and funding of the tasks are accomplished by the cognizant services.

The Air Force's Aeronautical Systems Division, Rome Air Development Center, and Naval Surface Weapons Center have management responsibility for most of the testability efforts. They have awarded contracts to industry to conduct most of the research. The goal is to implement the design for testability concept as early as possible.

Air Force efforts

In 1977 the Rome Air Development Center began, as part of its reliability and maintainability efforts, a testability program to address the problem of inadequate and expensive fault detection and isolation capabilities in electronics systems. To develop a testability engineering discipline, various aspects such as testability criteria, causes of unnecessary equipment removals, and false alarms were studied. Work has progressed to the point that testability design guides are being developed and issued.

The Air Force's Modular Automatic Test Equipment program, at the Aeronautical Systems Division, was established to obtain more supportable and affordable automatic test equipment. The program includes developing an avionics testability design guide for avionics equipment. The guide has been published and distributed to the other services for review and comment. Also, the Aeronautical Systems Division has drafted a testability specification for weapon systems, and a new Air Force policy requires that all future systems have 100-percent fault detection/fault isolation capability.

Navy efforts

The Navy's testability efforts include the publication of a joint-service built-in-test design guide and the establishment of a built-in-test/testability improvement program. In addition, the Navy as part of a triservice effort is monitoring the incorporation of the concept in the multimillion dollar Very High Speed Integrated Circuit program.

The Naval Material Command has taken some steps to implement testability. A recent Navy policy requires that testability be included as a top-level priority in acquisition programs and included in all contract specifications and contractual statements of work. According to the Acting Vice Commander of the Naval Electronic Systems Command, these actions are being taken, although the Navy lacks the design discipline and tools to adequately implement the testability concept. Efforts are also underway to prepare a new military standard for electronic equipment that will incorporate design for testability in the weapon system acquisition process. The Naval Surface Weapons Center and other Navy laboratories are attempting to define data to be included in the new military standard. Testability will become one of the elements traded off along with cost, performance, and logistic considerations on a case-by-case basis.

Army efforts

According to an Army official, the Army has not played a major role in the Joint Logistic Commanders' design for testability program due to a lack of funds. However, they have done limited research in improving testability in nonelectronic (mechanical) systems.

BENEFITS HAVE NOT BEEN PROVEN

Although the development and implementation of the design for testability concept has progressed to the point where design guides are being prepared and issued, no serious effort has been made to demonstrate that its benefits will exceed costs, if implemented. In 1976 the Navy attempted to examine one aspect of testability. The study recognized that incorporating built-in-test would increase the cost of a weapon system and asserted that these costs would be more than recouped during the operational life of the system. This claim was based on projections because actual cost data does not exist.

Proponents of testability have attributed numerous benefits to the concept, including reduced repair times, lower support costs, the need for fewer spares and complex support equipment, reduced life-cycle cost, better factory testing, improved availability, and improved performance monitoring. However, none of

these claims have been substantiated. For example, the Industry/Joint Service Automatic Test Project has claimed that weapon system operational availability could be potentially increased by 30 percent, and support costs could be reduced even though analyses supporting these assertions have not been made because the data to evaluate the benefits does not exist.

#### LIMITATIONS ARE NOT FULLY KNOWN

Just as the benefits have not been quantified, the services have been unable to quantify the limitations associated with implementing the design for testability concept.

The limitations, as recognized in a Joint Logistic Commanders' document, are many. There will be increased development and hardware costs to incorporate the concept into the weapon systems design. The document further points out that the increased test circuitry will affect reliability, presumably because there will be more circuits that could fail. This, in turn, will affect weapon system availability. Performance will also be affected because of the increased weight, space, and power required to accommodate the additional test hardware.

In addition, a Navy expert in design for testability stated that since weapon systems will become more complex, production costs will increase. This is due to the increased difficulty in manufacturing. Neither the Joint Logistic Commanders' document nor the Navy expert had quantified these limitations or documented that the costs would not exceed the benefits.

#### VIEWS OF AGENCY OFFICIALS

We discussed our findings, conclusions, and recommendations with officials of the Office of the Secretary of Defense, Joint Logistics Commanders Panel, Rome Air Development Center, Air Force's Aeronautical Systems Division, Naval Electronic Systems Command, and Naval Surface Weapons Center.

Agency officials generally agreed that the cost effectiveness of the concept has not been proven. They said that it would be beneficial to do a cost-effectiveness study, but an adequate data base is not available. They also said that in the weapon system acquisition process, design for testability will be traded off with cost, performance, and logistic considerations on a case-by-case basis. All agreed that for certain weapon systems, the concept may be used regardless of its costs to implement because of a desire to maintain a high level of readiness.

We agree that after implementing the concept, case-by-case analyses are necessary and should be done. However, we believe that institutionalizing the concept should be based on more than engineering judgment as is the case now. The concept needs a

valid data base on which analyses can be based and, if necessary, prototypes tested and evaluated.

CONCLUSIONS

We fully support and are encouraged by DOD's efforts to solve the field testing problems that are plaguing major weapon systems. We agree that one way to accomplish this is by implementing the design for testability concept and that it deserves high management support. Our note of caution, however, stems from other recent attempts to solve the problem that have not been as successful as originally thought. Automatic test equipment and built-in-test features have, in some cases, actually reduced weapon system reliability and availability.

Although the concept shows significant promise to enhance the testing capability of weapon systems, its benefits and limitations have not been quantified. We believe the benefits and limitations should be quantified and compared before the concept becomes a formal part of the acquisition process.

RECOMMENDATION

We recommend that the Secretary of Defense require the services to determine if the benefits of design for testability concept exceed its limitations before it is fully implemented within DOD and made a part of the weapon system acquisition process. This could be done by (1) establishing a data base to identify testability costs and the affect on reliability, availability, and maintainability and (2) prototyping a system designed for testability and comparing it to a similar system developed using standard design techniques.

- - - - -

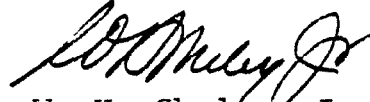
As you know, section 236 of the Legislative Reorganization Act of 1970 requires the head of a Federal agency to submit a written statement on actions taken on our recommendations to the House Committee on Government Operations and the Senate Committee on Governmental Affairs not later than 60 days after the date of the report and to the House and Senate Committees on Appropriations with the agency's first request for appropriations made more than 60 days after the date of the report.

We are sending copies of this letter to the Director, Office of Management and Budget; the Chairmen of the House and Senate Committees on Armed Services and Appropriations, House Committee

B-208483

on Government Operations, and Senate Committee on Governmental  
Affairs; and the Secretaries of the Army, Air Force, and Navy.

Sincerely yours,

A handwritten signature in cursive script, appearing to read "W. H. Sheley, Jr.", written in dark ink.

W. H. Sheley, Jr.  
Director