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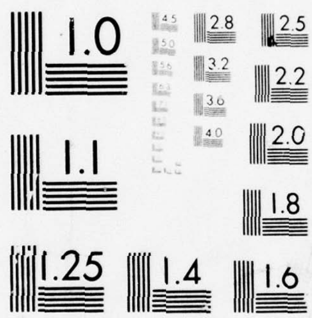
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# DEFENSE SYSTEMS MANAGEMENT COLLEGE

DEPARTMENT OF DEFENSE
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## PROGRAM MANAGEMENT COURSE
## INDIVIDUAL STUDY PROGRAM

**CONSIDERATIONS IN APPLYING STANDARD ELECTRONICS IN MILITARY SYSTEMS**

STUDY PROJECT REPORT
PMC 77-1

STEVEN C. HENDRICKSON
INDUSTRY IBM

FORT BELVOIR, VIRGINIA 22060

# CONSIDERATIONS IN APPLYING STANDARD ELECTRONICS IN MILITARY SYSTEMS

Individual Study Program

Study Project Report

Prepared as a Formal Report

Defense Systems Management College

Program Management Course

Class 77-1



by


Steven C. Hendrickson
Industry IBM


May 1977

Study Project Advisor
CDR Herbert Woods, USN

This study project report represents the views, conslusions and recommendations of the author and does not necessarily reflect the official opinion of the Defense Systems Management College, the Department of Defense or the IBM Corporation.

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DEFENSE SYSTEMS MANAGEMENT COLLEGE

STUDY TITLE:

Considerations in Applying Standard Electronics in Military Systems

STUDY PROJECT GOALS:

To define those areas that must be considered and the trade-offs that must be made in evaluating standardized electronics.


STUDY REPORT ABSTRACT:

The purpose of this study was to examine the concept of standardized electronics. This was done in terms of utilization of technology and cost and reliability impacts to a system. The intent is to aid program management in defining the areas that should be considered when deciding on unique or standardized electronics for their system.

The basis for the study was experience gained in applying the Navy Standard Electronic Module program to the AN/BQQ-5 and AN/BQQ-6 sonar systems and information available from current DOD literature.

The paper concludes that many elements of electronic standardization are attractive individually but some factors may be negative for some system applications.


Subject Descriptor: Standardization
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| Steven C. Hendrickson | 77-1 | May. 1977 |

# EXECUTIVE SUMMARY

One alternative program management has in attempting to reduce acquisition and life cycle costs is to use an available hardware configuration for system electronics. As one military program manager put it, electronics standardization "smells good". There are, however, many aspects that a program manager should be aware of in making his decisions about which, if any, standardization approach to take and how much of the available program to apply to his system requirements. He should have a feel for what gains and/or sacrifices he will have compared to unique electronics development. Areas of consideration include relative reliability, size, utilization of current technology, cost and schedule factors. If a standardization concept is decided on, then the amount of tailoring of specifications desired should be considered.

The intent of this paper is to present these considerations using, as a baseline, the Navy developed Standard Electronic Module Program (SEMP) as it was applied to the AN/BQQ-5 and AN/BQQ-6 submarine sonar systems.

Data used in the development of this paper came from existing writings on the subject (see reference list) as well as the author's experience as SEM program manager for

IBM. The background used in describing the current defense systems acquisition environment came from material presented at the DSMC Program Management Course 77-1.

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# SECTION I

# INTRODUCTION

The intent of this paper is to examine the use of standardized electronics from the point of view of current DOD policy, technology trends and experience gained from the application of standard electronics to the AN/BQQ-5 and AN/BQQ-6 submarine sonar systems.

This information should be useful in understanding the options available and assessing limits of effectiveness in applying standardization to electronics procurement.

The baseline for this study is the Standard Electronic Module Program (SEMP). The SEMP is currently the oldest and largest such activity in the DOD and represents the largest experience base available. The SEMP has been thoroughly developed and is comprehensive in scope. This allows latitude in its application depending on the development stage and system objectives. Qualified Products List (QPL) requirements can be applied or "special" types developed using the basic configuration and tailored specifications.

Standardization is not a panacea for all the ills associated with electronics. Its application can have negative effects, particularily relative to technology utilization and circuit density. The discussion of these factors should be helpful in determining if unique electronics development would be more desirable for a particular system.

The increasing portion of the defense dollar being allocated to electronics and the decreasing military influence on microcircuit technology direction is causing considerable concern in the DOD. Committees have been set up and studies initiated. A separate section in the paper provides an overview of these activities that relate to the future directions DOD might take in electronics procurement.

## SECTION II

## THE CURRENT ACQUISITION ENVIRONMENT

### Standardization and Current DOD Policy

Standardization has always been an attractive concept:

> Standardization, on a big program or a small program, on a defense program or a commercial program, provides many interrelated advantages. These include reduced item cost through use of readily available items, reduced assembly and installation costs for items as a result of standard tooling, more predictable reliability through use of items with established service histories, reduced numbers of total types of items requiring initial procurement and subsequent logistics systems, improved maintenance by elimination of odd or unusual items, and reduction of testing and qualification, all of which adds up to improved potential for meeting schedule and cost goals through elimination of duplicative hours and costs required for development and use of similar items. (3:18)[1]

On the other hand, current government concern with proliferation of "how to" specifications which inhibit the application of state-of-the-art technology has caused a number of new directives to be issued. An example of this is Executive Circular A-109 which states that Federal agencies, when acquiring major systems, "will express needs and program objectives in mission terms and not equipment terms to encourage innovation and competition in creating, exploring,

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[1] This notation will be used throughout the report for sources of quotations and major references. The first number is the source listed in the bibliography. The second number is the page in the reference.

and developing alternative system design concepts". (4:1) The initiative for such direction comes from evidence that the increasing layering of specifications on system contractors is having an adverse effect on competition and technology utilization.

It is encumbent on the program manager to evaluate all aspects when considering electronics standardization. He should also apply the optimum amount of specification tailoring to whatever hardware gets developed:

> In an area as dynamic as electronic technology, the vast DOD system of military standards and specifications is too sluggish to follow the rapid advances in technology. But by providing instructive guidelines for the uninitiated, it does have the valuable function of admitting novices in military electronics design and manufacture to the competition for development and production of hardware. (6:34)

## The Standard Electronic Module Program (SEMP)

There are three fundamental levels at which standardization has been applied to electronics, i.e.: components, plug-in modules and functional boxes (radios, computers, etc). This paper uses plug-in modules as a basis for comparison, however some of the considerations are equally applicable to the other two levels. Further information may be obtained on component and box (form, fit and function) standardization by reading the appropriate references and other current literature.

Plug-in modules in general and the SEMP in particular currently have the most highly developed areas of electronic standardization for military systems. The SEMP is a Navy developed program that is now seeking tri-service implementation. This paper uses the SEMP only as a baseline for discussion about the standardization concepts considered. An overview of the SEMP has been included as Appendix A to aid the reader in understanding examples cited in the text.

SECTION III

COST CONSIDERATIONS

Development and Acquisition

1. Competitive Procurement

All studies on the subject of government procurement costs support the virtues of competition (9:41,57). Standardization has, as one if its motives, the encouragement of competition by increasing the procurement base. The hoped for effect would be the application of the best manufacturing techniques in a high volume competitive market with a large number of supplies (5:23 and 10:20).

Using the SEMP as an example, the success in this area has been marginal. The number of qualified suppliers has actually been reduced through the application of increasing requirements (7:2, 8:2,3,4,5). Ironically one of the drivers for the increasing number of specifications (see Section III of Appendix A) has been an attempt to give the SEMP the widest possible tri-service acceptability and usage by the application of Qualified Products List (QPL) requirements. This reduces the options in production and test techniques and tends to flatten differences between potential suppliers. The market for fully qualified, common usage SEM product has remained fairly constant. This market, as seen by potential suppliers, is further diluted by the users desire to maintain multiple sources rather than have the winner-take-all (5:23).

A technique that has been employed by some SEM users has been to determine what requirements are necessary to their particular program and tailor specifications accordingly. This effectively increases the number of potential suppliers and allows them to apply their most cost effective production and test techniques. Considerations in doing this tailoring are discussed in the balance of this paper.

## 2. Development Costs

Module or functional level development costs could be completely avoided by the system if all required functions were already available from a standardization program (10:11). More probably, some functions will be available, some will not. Those that are not will have to be developed. Possible offsetting costs should be considered for those functions which are available from a given standardization program. These costs include interconnection (i.e. wirewrap backpanels versus hardened circuitry), packaging and any size and weight penalties.

Two options are available if unique functions are required within the standard configuration. They can be developed as "specials" which use only the form factor and mechanical configuration or they can be developed as standards applying all program requirements.

The qualification and documentation requirements of the later approach are expensive (1:24 and 9:10,12). This must be traded off against any potential benefits to the system and the DOD through incorporation of the function into the major standardization program.

Here again, a technique employed by users has been to tailor specifications to optimize benefits. One such technique has been to apply a documentation review instead of a full qualification to particular module types thus avoiding the extensive testing required for qualification (see Section IV and Figure A3 in Appendix A). Whatever risks that are involved in this approach will be measurable early because unqualified new module types are usually used in initial systems because the module documentation and qualification process is long compared to first system development.

3. Manufacturing and Test Costs

Most of the manufacturing activities associated with electronic module production are straight forward, particularily when dealing with the kind of construction shown in Figure A-1 of Appendix A. The same techniques and equipment generally can be employed when producing any module part number.

Test requirements, however, are unique to each part type to a great extent. Section IV and Figure A-4 of Appendix A shows the extent of testing required by the SEMP. The cost, both in developing the capability and applying it, demands careful analysis of its requirement.

Figure A-4 shows that initially, new module types are applied in systems with only a "build test" applied. This test, for digital module types, usually consists of a 1's and 0's fault locating tests implemented on an existing test capability.

Results of module testing for the AN/BQQ-5 and AN/BQQ-6 systems, both before and after application of fully specified tests, (see Figure A-4) showed no measurable difference. The average fallout at both module level and system level test remained the same.

This is explained by the fact that the electrical components used to manufacture the modules are tested to requirements that preclude failure at higher assembly levels. A simple fault locating test of the assembled module is generally all that is required to detect manufacturing defects in the module. The tests called out in the Detailed Module Specification (DMS) are, to a large extent, redundant with those applied at the component level.

Another factor is that a test designed to preclude a problem experienced by one manufacturer or for one period in time is sometimes included in a specification applied to all manufacturer's for all time. An example of this is the SEMP requirement for temperature cycling of each module (Section IVB of Appendix A). This cycling is intended to screen for a type of printed circuit board or solder joint failure. Such a failure has not occurred in the hundreds of thousands of modules delivered to the AN/BQQ-5 and AN/BQQ-6 systems. Temperature cycling is applied on a sample basis for those systems.

There will be a tendency in any standardization approach for specifications and requirements to proliferate based on "what if" considerations and single or short term occurences. This is particularily true of test and inspection requirements at all levels, from components on up.

The program manager should understand the test options available and their relative costs, benefits and risks in terms of his system.

<u>Operation and Support Costs</u>

According to the Electronics X study: "annual support costs for military electronics are now almost equal to the annual procurement costs and constitute more than one-third of all annual expenditures on military electronics" (6:1). This continuing growth of the fraction of the total DOD resources needed for operation and support has created a high level of concern (11:1).

The amount of operation and support costs to be avoided by employing standard electronics is determined to the largest extent by how widely used it becomes. Equally important is how many elements it provides that are common between systems. These factors will allow for common stocking, reduced spare counts and other support elements. Achieving tri-service usage and common stocking is a high priority goal of the SEMP. (2:1, 18:1)

It is intuitive that O and S savings will be realized by standardization but quantifying them is a problem. Data collection and feedback from deployed systems has not been sufficient to make trade offs between O and S savings and any additional development and opportunity costs incurred by standardization (10:12). The necessity for this data has been recognized by the DOD and, hopefully, better tools will become available for analyzing relative costs (6:3, 11:1).

Failure to use all the commonality benefits of standardization will subvert some of the potential gains. Some users of the SEMP, for instance, have set up their own configuration controls and item numbering systems on top of the ones controlled by the SEMP for the same modules. This, of course will reduce that systems ability to draw from a common stock.

A particularily attractive feature of the SEMP is the low cost of the majority of replaceable units. This supports a throwaway maintenance concept. This seemingly straightforward assumption is not without pitfalls either:

> Many times the total logistics management job isn't done well, often due to funding or scheduling constraints and even outright neglect. As a result, for instance, training or technical procedures may not be properly prepared and validated.

As a consequence, the maintenance man may not be able to easily find the fault when the replacement unit fails because he has been poorly trained or given inadequate diagnostic aids. Then, he is likely to inadvertently replace units that have not actually failed, or he may even induce failure during the maintenance process. In either case, the replacement rate for the unit will be higher than predicted and repair of what would have been a throwaway replacement unit will be encouraged. The analyst can attempt to avoid this fact of life by simply avoiding optimism during the design analysis, but the real solution must come from better logistics management and more complete implementation of logistics programs during the use of the product. (12:3)

## SECTION IV

## PERFORMANCE CONSIDERATIONS

### Application of Current Technology

One motive for the development of new electronics systems is to take advantage of the latest available technology in meeting a particular threat or system need. An effective standardization program must be able to accommodate changes in technology (5:10). This becomes difficult at the module level because of a fixed form factor envelope for standardized functions. A system need to maximize circuit density will generally require a unique functional configuration, particularily in the case of digital electronics. Increasingly higher levels of circuit integration and module density reduces system to system commonality. This reduced commonality will adversely affect life cycle costs which are benefitted by functional standardization rather than mechanical and physical aspects (13:2).

A desire of standardization programs is to protect the system from changes in technology. This is considered desirable because in the past technology changes have made some systems unsupportable in later years. The most common example given is that of vacuum tubes being displaced by transistors. The technique attempted is to standardize at a level where only input and output functions are specified making the unit or module "technologically independent". The constant or standardized item being the external configuration (14:31).

The SEMP employs functional specification to high usage digital module types. The specifications, however, are highly driven by the particular IC components available at the time. This makes it probable that the module can be built only with a certain set of components. It is unlikely that the same specifications could be met in the future by some other devices.

The evolution of technology (see following chart) requires that the adaptability of the selected hardware configuration be considered. If it precludes the use of mainstream technology, the expected favorable cost impact might reverse and become a burden. Planning for "design updating" has been suggested as the most powerful technique for managing life cycle support/technology impact (15:10).

LOGIC CIRCUITRY TRENDS

| | 1970 | 1975 | 1980 |
|---|---|---|---|
| Cost | 1 | 0.66 | 0.33 |
| Density | 1 | 2 | 4 |
| Performance | 1 | 2 | 3 |
| Power | 1 | 1 | 0.5 |
| Technologies | TTL | TTL<br>STTL<br>LSTTL | TTL<br>STTL<br>LSTTL<br>$I^2L$<br>MOS |

## Reliability

Some adverse system reliability impacts can be avoided if fully developed hardware is used. Two factors that should be considered are:

1. System reliability is to some extent a function of the number of interconnects between elements. The greater the circuit density of each element or module the fewer interconnects required.

2. Temperature is a chief cause of field failure of electronic equipment (13:56). Careful consideration must be given to the use environment when selecting a hardware configuration and method of cooling.

## SECTION V

## CURRENT STUDIES AND FUTURE IMPLICATIONS

In his report to the 95th Congress on the DOD Program of Research and Development for FY 1978, Malcolm R. Currie states:

> A good example of the opportunities and the potential payoff in lower life cycle costs for military systems is in the general area of electronics. We are examining the feasibility of a greater use of custom large-scale integrated circuitry (reducing component types and extending technology life expectancy); we will soon establish a standard electronic module form factor for avionic modules (enhancing the shop level repair process) and we will apply the commercial airline standardization practice of form-fit function on selected avionic equipments. We are also attempting to develop unique standardization approaches for those techniques which are changing rapidly and therefore force early obsolescence; for those which have military potential but are considered costly in low volume production (i.e., forward looking infrared systems) and for those which are influenced by the commercial sector more so than by the military (computers, semiconductor devices, etc). (16:1X-15)

He also stated, on the subject of tailoring specifications:

> Study findings confirmed the need for improved controls over the application of specifications and standards in the acquisition process. Policies and procedures to control the blanket application of specifications and standards and to require their cost-effective tailoring in acquisition programs have been formulated and issued. (16:1X-16)

The initiatives embodied in these statements have taken the form of several on-going studies. The Naval Avionics Facility, Indianapolis and the Naval Weapons Support Center, Crane are studying the extension of modular standardization into avionics (13). AdHoc subpanels have been established by DOD (Installation and Logistics) to address modular and form, fit and function electronics standardization (9:82). A study has been contracted for by DOD (I and L) with the Institute for Defense Analysis on the subject of: "Large Scale Integrated Circuits in Military Systems: The Potential for Cost Avoidance and Performance Improvements by the Use of More Highly Integrated Circuits". A final report is expected by June, 1977 (17:I).

The use of these studies and the other references is recommended in reviewing the applicability and level of electronics standardization for a particular system.

## SECTION IV

## SUMMARY AND CONCLUSIONS

The current electronics acquisition environment creates problems for program management because of the dynamics involved, namely:

a. Rapidly evolving technology

b. Decreasing DOD portion of electronic device procurements causing a reduction in the control of technology direction.

c. Proliferation of part types and their supporting elements.

d. Apparent reductions in system reliability even as individual component reliabilities have increased.

Standardization of electronic elements is seen by many as the vehicle by which the DOD builds up its electronics procurement base and control, reduces item proliferation and spare size and improves system reliability. This study of the parameters affecting this assumption reveals that standardization of electronic elements can improve some factors for some systems. Consideration must be given, however, to factors which may actually degrade system cost or performance or which might offset some expected benefits.

In evaluating the application of electronics standardization to his system, the program manager or assigned project engineer should consider:

Competitive Procurement

Multiple sources and the hoped for effect of price reductions may not be achieved because of the flattening effect of "how to" specifications. Tailoring of requirements to a particular system can be useful in reducing this effect.

Cost

A considerable amount of the development cost for a system can be avoided by applying standard electronics. This is dependent on the amount of off-the-shelf items that can be used and any packaging size and weight penalties.

Manufacturing and test costs are largely controllable by the tailoring of specifications to particular system requirements.

Support costs for electronics with multiple system usage and common support will be lower. The amount of these savings is directly dependent on both the extent of usage by different systems and the number of elements interchangeable between systems. Common stocking is necessary to reduce the total spares inventory. Good logistics support planning will still be required to minimize these costs.

## Application of Technology

Electronics standardization should not be used as a hedge against technology changes as there is some danger of the opposite effect. Planning for "design updating" should be done to accommodate evolving technology.

## Reliability

Reliability problems associated with initial hardware developments can be avoided by using functions already available. Consideration should be given to the affect circuit density and cooling systems have on reliability.

## Current Studies and Future Implications

The DOD proportion of the total electronics market is continually declining. This will continue to affect the available functions and hardware configurations.

Major DOD studies are being performed in the areas of large scale integrated circuits, standardization of avionics modules and specifying by form, fit and function.

## REFERENCES


1. Booze, Allen, Applied Research, Inc., Study of Electronic Packaging Standardization Concepts, October, 1969.

   This study provides the baseline conclusions and motivations for electronics standardization current in 1969.

2. Wyatt, John A., "Requirement for an Independent Federal Supply Class for Standard Electronic Modules", memo dated 9 March 1977. Mr. Wyatt is the SEM project manager for NAVELEX.

3. Rockwell, W. F., Jr., "Standardization - Taxpayer Savings and Improved Performance", Defense Management Journal, April, 1973.

   This article approaches standardization from a broad point of view and covers piece parts through drawing practices.

4. Witt, Hugh E., "Major Systems Acquisitions", Executive Office of the President, Office of Management and Budget, Circular A-109, 5 April 1976.

   This directive establishes the policy that major systems are to be specified in terms of mission needs rather than in terms of equipment.

5. Gates, Howard P. et al, Institute for Defense Analysis, Electronics X: A Study of Military Electronics. Volume I: Executive Conspectus, January, 1974.

   This study provides a comprehensive analysis of the current direction and problems of electronics acquisition for defense systems. Recommendations are made as to the direction DOD policies should take in this area.

6. Volume II of Reference #5. This is the body of the Electronics X study.

7. "SHP Module Matrix Chart", NAVORD Drawing 2658999, 14 August 1970.

8. "Qualified Products List of Products Qualified Under MIL-M-28787, SEMP, General Specification for", Naval Weapons Support Center, 22 November 1976.

9. Donald E. Blinn, William D. Yri, Air Force Institute of Technology, *Acquisition Management of Common Avionics in the United States Air Force*, September, 1975.

This thesis examines common avionics acquisition and recommends form, fit and function specification as a standardization approach.

10. Logistics Management Institute, *Economic Feasibility of Standardized Avionics*, May, 1974

This study also favors a form, fit and function approach for avionics.

11. Hon. W. P. Clements Jr., "Reduction of Outyear Operating and Support (O and S) Costs". The Deputy Secretary of Defense Memorandum for the Secretaries of the Military Departments, 28 February 1976.

In this memorandum, the deputy secretary expresses his concern for increasing O and S costs and for improving their visibility and control.

12. Robert L. Drake, "Throwaway Maintenance - Fact or Fiction", *Logistics Spectrum, Society of Logistics Engineers*, Summer, 1975.

13. Naval Avionics Facility, Indianapolis (NAFI), *Standard Electronic Modules Exploratory Development Module Packaging Studies FY 1976 Summary Report*, 1 September 1976. (NAFI publication TR-2146)

These studies involve the extension of the SEMP into higher levels of integration and functionalization. Particular attention has been paid to avionics requirements.

14. Carroll E. Garrison, "Technological Progress in Electronic Components, A Life Cycle Support Problem", Defense Systems Management Review, Vol I, No. 1, Winter, 1976.

15. Robert M. Lockerd, "Electronic Technology Progress and Life Cycle Support - An Industry View", Defense Systems Management Review, Vol I, No. 2, Spring, 1977.

Mr. Lockerd states that the detrimental impact of technology development on life cycle support has been overstated. He is an advocate of planned design updating to accommodate evolving technology.

16. Department of Defense, DDR & E, Director's Statement (95th Congress, First Session), "Program of Research, Development, Test and Evaluation, FY 1978," Washington, D.C., 1977.

This statement to the Congress outlines the thrust of DOD R, DT & E programs.

17. Michael I. Keller, OASD (I & L) Interview held on March 17, 1977.

Mr. Keller is a co-chairman of the Electronics Panel of the Defense Material Specifications and Standards Board. This panel is chartered to "improve the posture of the DOD in electronic equipment development, acquisition and support".

18. John A. Wyatt, "Designation of Tri-Service SEM Program Support Facilities", memo dated 9 March 1977.

# Appendix A

## SEMP OVERVIEW

### I. History

The Standard Electronic Module Program (SEMP) evolved from a study at the Naval Avionics Facility, Indianapolis (NAFI) in the early 1960's that was performed to determine options in containing proliferation of electronic equipment configurations (1:A20). A family of functional electronic plug-in modules was developed to serve as common building blocks for systems development. Since then the SEMP has employed three levels of technology growth (DTL, TTL and STTL) within essentially the same hardware configuration.

The SEM Program presently contains approximately 300 types and over five million modules have been deployed in some 70 different systems, mostly shipboard. The program is presently (March, 1977) being coordinated for Tri-Service implementation (2:1).

### II. General Description and Size

SEMs are a family of dimensionally and mechanically specified plug-in replaceable elements. Each module performs a particular electronic function which is either explicitly stated or the design is disclosed (1:A14).

In large usage digital module types, the function is usually determined by the electronic component. All pins from the component are brought out and the function is duplicated as many times as there are active components.

The basic SEM size is 2.62 inches wide, 1.95 inches high and 0.290 inches thick. Modules may also be made in larger increments of these width and thickness dimensions. Typical module construction is shown in Figure A1.

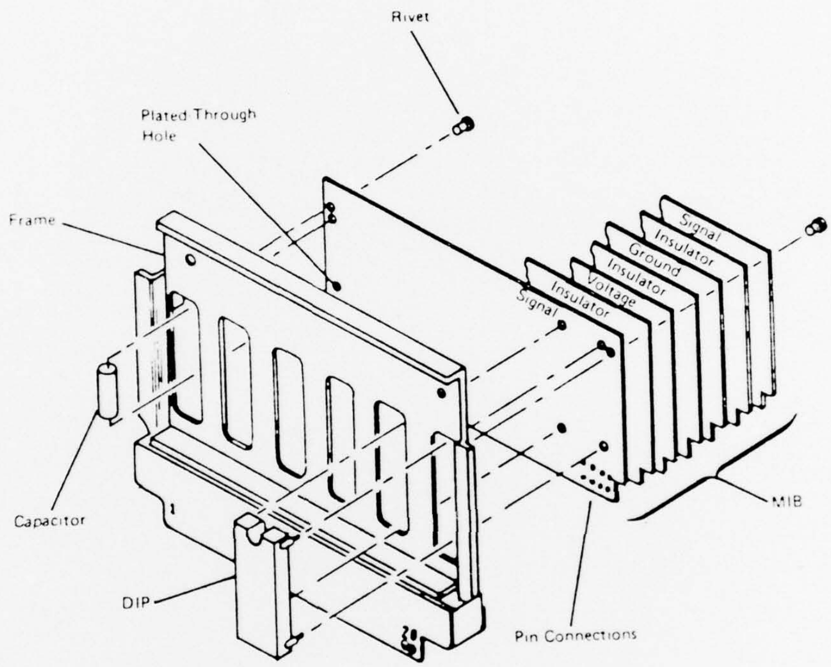
III. Applicable SEMP Specifications and Standards

A. Specification and Standards Peculiar to the SEMP

1. MIL-M-28787 SEMP General Specification
General Specification for the SEMP. This specification establishes the quality assurance and procurement requirements.

2. Detailed Module Specification (DMS)
These are slash sheets to MIL-M-28787 that contain specific requirements applicable to a particular module part number.

3. MIL-STD-1389 SEM Design Requirements
This standard contains the design and construction requirements for SEMs.




Typical SEM Construction

Figure A-1

4. MIL-STD-1378 SEM Application Requirements

This standard provides the equipment contractor with specific direction for implementation of the SEMP.

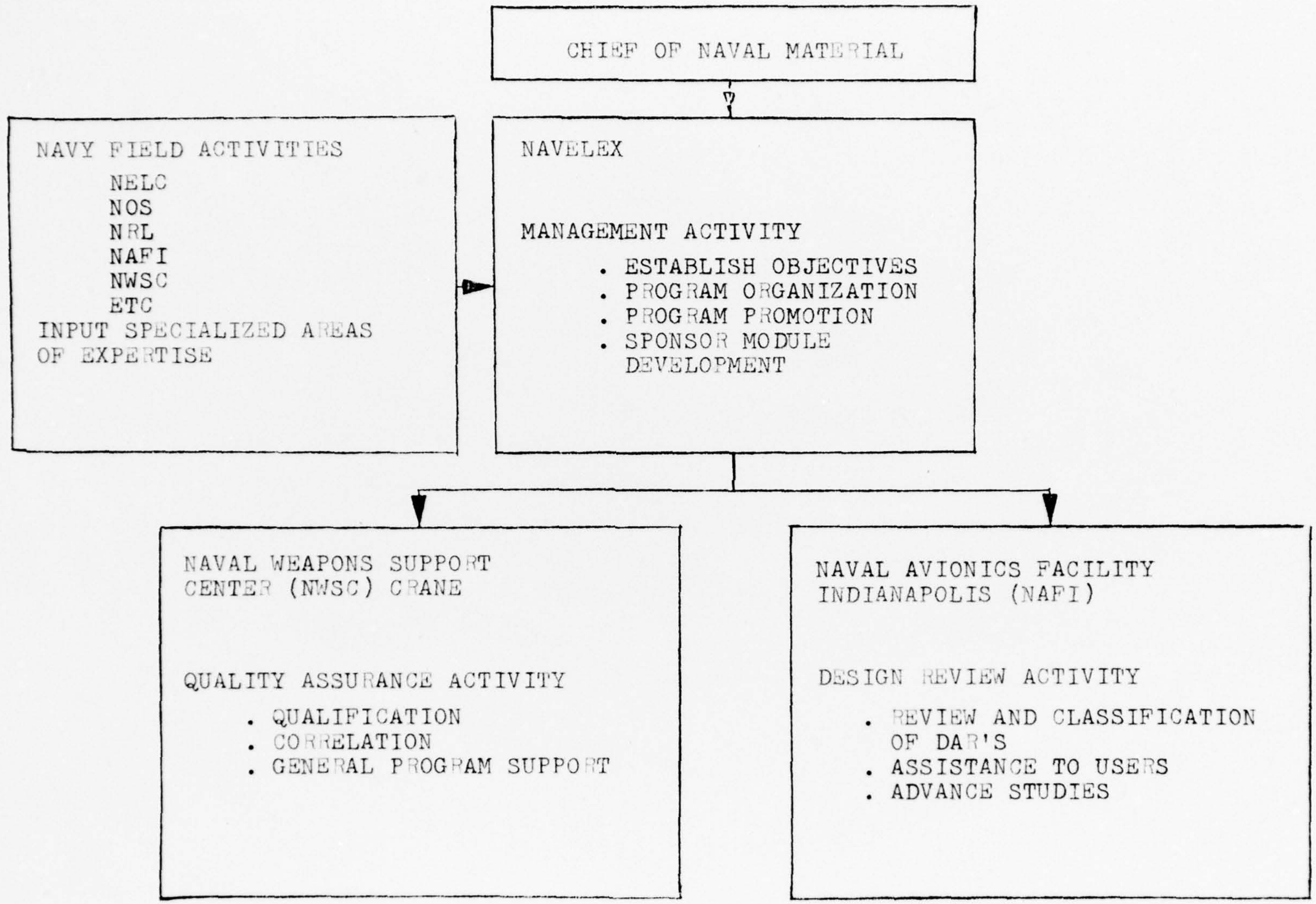
B. Other Major Specifications and Standards Applied to the SEMP

| | | |
|---|---|---|
| 1. | MIL-M-38510A | General Specification for Microcircuits |
| 2. | MIL-STD-883 | Test Methods and Procedures for Microelectronics |
| 3. | MIL-STD-1495 | Multilayer Printed Wiring Boards for Electronic Equipment |
| 4. | MIL-P-55640A | Printed Wiring Boards Multilayer (Plated-Through Hole) |
| 5. | MIL-P-55617A | Plastic Sheet, Thin Laminate, Metal Clad |
| 6. | MIL-G-55636A | Glass Cloth, Resin Preimpregnated (B Stage) (For Multilayer Printed Wiring Boards) |

IV. Typical SEM Test and Inspection Requirements for Digital Type Modules

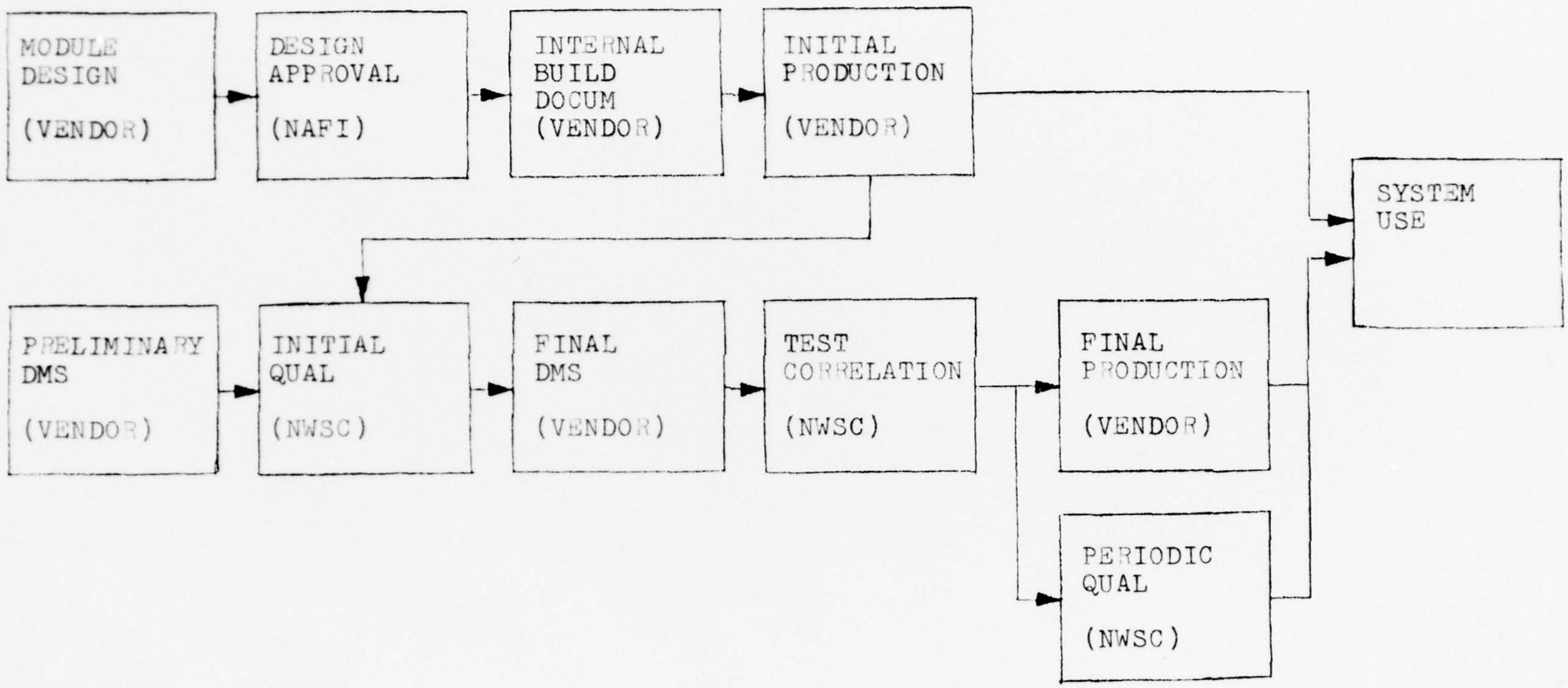
A. Tests performed on 100% of the modules produced (designated as X tests in the DMS).

1. Static output voltage, logic 0.
2. Static output voltage, logic 1.
3. Input current, logic 0.
4. Input current, logic 1.
5. Output short circuit current.




SEM Organization (Navy)

Figure A-2




SEM DEVELOPMENT FLOW

AN/BQQ-5 & AN/BQQ-6

Figure A-3

B. Temperature Cycling on 100% of Production

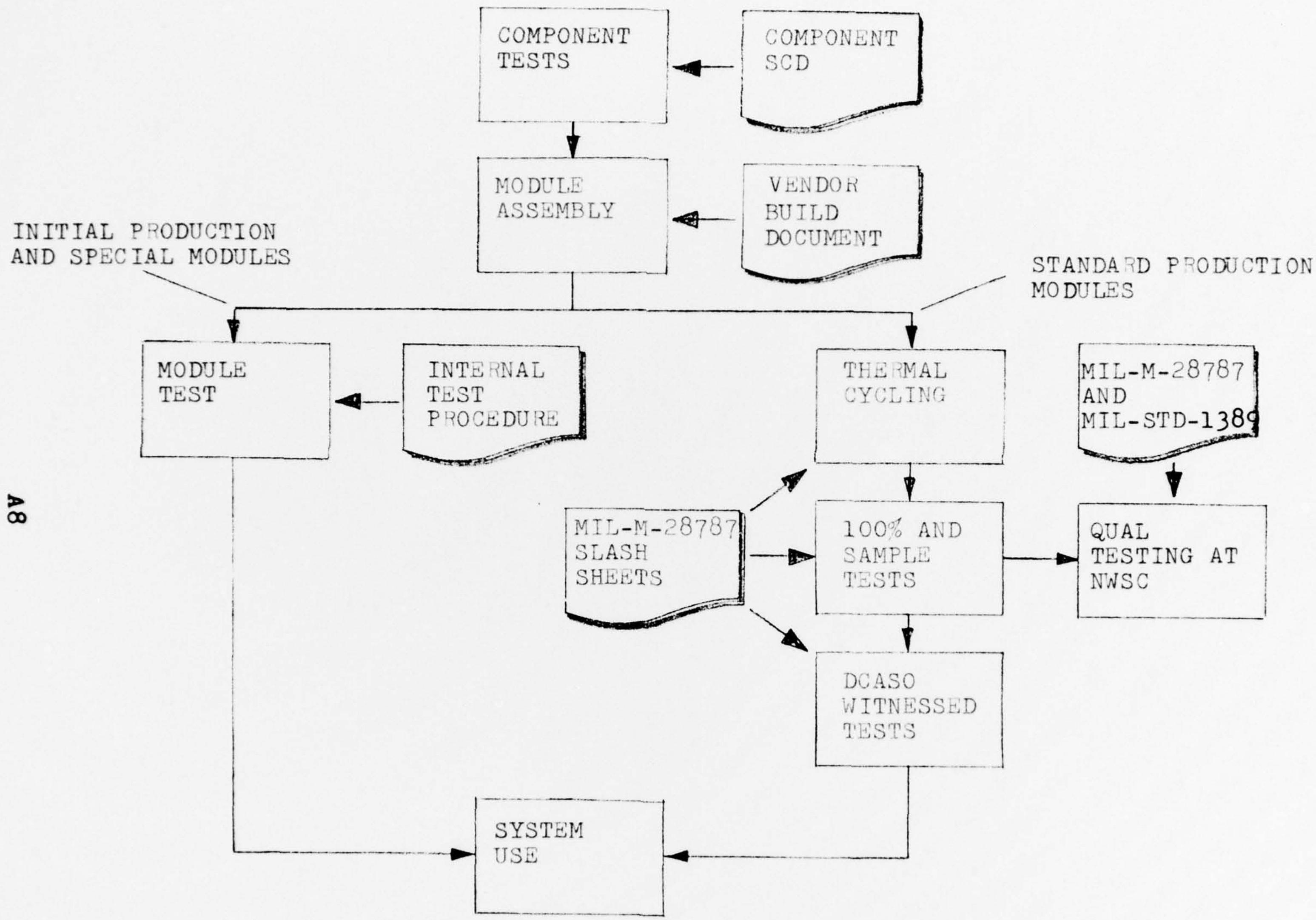
1. Non-operating
2. -55°C to +85°C
3. 15 minutes at each extreme, 5 minute transition

C. Test performed on 1% or 2 modules from each lot, whichever is higher (designated as S tests in the DMS)

1. Power supply current, logic 0
2. Power supply current, logic 1
3. Rise time
4. Fall time
5. Turn on delay
6. Turn off delay
7. Power supply transient rise time
8. Isolation
9. $V_o$ low loaded
10. Input breakdown current

D. Additional electrical tests performed during qualification on 5 modules of each type every 6 months (designated as Q tests in the DMS).

1. Output crosstalk, logic 0
2. Output crosstalk, logic 1
3. Power supply transcient amplitude
4. Unused pin isolation
5. Input capacitance




Typical SEM Manufacturing and Test Flows

Figure A-4