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MILITARY HANDBOOK

PROGRAM MANAGERS GUIDE
FOR THE
STANDARD ELECTRONIC MODULES PROGRAM

FSC 5963

DEPARTMENT OF DEFENSE
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Program Managers Guide for the Standard Electronic Modules Program

1. This handbook was developed by the Naval Electronic Systems Command in accordance with established procedure.

2. This publication was approved on 3 September 1982 for printing and inclusion in the military standardization handbook series.

3. This document provides valuable information and guidance to program managers concerned with the implementation of the Standard Electronic Modules Program. The handbook is not intended to be referenced in acquisition specifications except for informational purposes, nor shall it supersede any specification requirements.

4. Every effort has been made to reflect the latest information on the Standard Electronic Modules Program. It is the intent to review this handbook periodically to insure its completeness and currency.

5. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Naval Electronic Systems Command, ATTN. ELEX 8111, Washington, DC 20363 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

FOREWORD

This handbook is intended as a guide for program and acquistion managers who are responsible for electronic system development and acquisition programs. It presents pertinent information on the Standard Electronic Modules Program (SEMP) which will enable the program manager to make judgments as to the applicability of Standard Electronic Modules (SEM) for a particular program. Information on methods of specifying SEMP requirements in system/equipment acquisition documents, life cycle cost analysis, proposal evaluation criteria, and contract monitoring considerations are also discussed.

All general documents and the related Federal Supply Class (FSC) assignment for Electronic Modules are tri-service coordinated. This handbook describes the Navy's SEMP. The use of SEM by the other services has been limited, however, SEM have been used in a number of developmental equipments for the Army and Air Force. The program is also being studied for NATO use or adaptation.

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1. PROGRAM MANAGERS GUIDE FOR THE STANDARD ELECTRONIC MODULES PROGRAM

1.1 Introduction. The term "electronic module" as used in Federal Supply Class 5963 designates an electronic component designed for use in various equipment or end item applications, and capable of controlling voltage and/or current to produce gain, oscillation, switching, or similar integral electronic functions. It consists of a collection of miniaturized electronic parts and/or elements in a single replaceable package with plug-in mounting which will also complete the required electrical connections. It is not normally subject to disassembly as distinguished from such items as CIRCUIT CARD ASSEMBLY and ELECTRONIC COMPONENTS ASSEMBLY.

Standard Electronic Modules (SEM) are electronic modules designed and procured in accordance with MIL-STD-1389 and specification MIL-M-28787, respectively.

The Standard Electronic Modules Program (SEMP) is an electronic module design standardization program Its purpose is to define and make available Standard Electronic Modules (SEM) that will reduce the cost and expedite the design and production of military electronic systems while improving their logistical support. The SEMP strives to guide new module development efforts in a manner that will enable usuage in other equipments, thereby providing for large production volumes and a broad competitive industrial base It allows for continuing cost reduction by the functional specification of module characteristics, thereby stimulating vendor innovation and competition as well as the application of advances in technology Such factors keep SEM within a price range which justifies their being discarded upon failure, rather than requiring repair Through the elimination of redundant design efforts, the need for repair facilities and large inventories of unique parts, the use of SEM has significantly reduced the cost of the key elements in equipment life cycle cost

1.2 Purpose. This handbook has been prepared for use by program managers responsible for the development and acquisition of electronic equipment It provides the necessary guidance for determining the initial applicability of SEM for military system applications, as well as for evaluating and monitoring those aspects of a program once a contractual requirement has been established. For maximum effectiveness, this handbook should be reviewed by program managers as early as possible in the acquisition planning period.

1.3 Scope. This handbook covers the relevant phases of an equipment development program which would be impacted by the decision to implement equipment hardware requirements with SEM. It specifically assists the program manager

a. In assessing the cost impact of SEM versus non-SEM electronic equipment implementations.

b. In preparing the appropriate SEM requirements within system acquisition documents.

c. In establishing a methodology for evaluating SEM configured system proposals.

d. In establishing an orderly procedure for operating and coordinating with SEMP support activities.

e. In monitoring the SEMP milestones within a system development program.

2 REFERENCED DOCUMENTS

2.1 Issues of documents. The following documents of the issue in effect on date of invitation for bids or request for proposal, form a part of this handbook to the extent specified herein.

SPECIFICATIONS

MILITARY

DOD-D-1000 - Drawings, Engineering and Associated Lists.

MIL-E-5400 - Electronic Equipment, Aerospace, General Specification for.

MIL-E-16400 - Electronic, Interior Communication and Navigation Equipment, Naval Ship and Shore. General Specification for.

MIL-S-19500 - Semiconductor Devices, General Specification for.

MIL-M-28787 - Modules, Standard Electronic, General Specification for.

MIL-M-38510 - Microcircuits, General Specification for.

STANDARDS

MILITARY

MIL-STD-961 - Military Specification and Associated Documents, Preparation of.

MIL-STD-1378 - Requirements for Employing Standard Electronic Modules.

MIL-STD-1389 - Design Requirements for Standard Electronic Modules.

MIL-STD-1634 - Module Descriptions for the Standard Electronic Modules Program.

MIL-STD-1665 - Test Equipment for the Standard Electronic Modules Program.

HANDBOOK

MILITARY

MIL-HDBK-217 - Reliability Prediction of Electronic Equipment.

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific acquisition functions should be obtained from the acquiring activity or as directed by the contracting officer.)

2.2 Other publications. The following documents form a part of this handbook to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

NAVMAT INSTRUCTION 4120.102 - Standard Electronic Modules (SEM) Program.

(Application for copies should be addressed to Commander, Naval District Washington, Supply and Fiscal Department (Code 514.3), Washington Navy Yard, Washington, DC 20390)

TP-526 - SEM Program Microprocessor Applications Handbook.

TP-527 - SEM Program Synchro Converter Applications Handbook.

- SEM System Application Report.

TP-528 - SEM Program Memory Applications Handbook.

TP-529 - SEM Program Thermal Applications Handbook.

TP-531 - In-Process Module Descriptions Handbook.

TP-532 - SEM Program Hardware Catalog.

- SEM Program Module Listing.

- SEM Notes Newsletter.

(Application for copies should be addressed to: Commanding Officer, Naval Avionics Center, ATTN: Code D965, 6000 East 21st Street, Indianapolis, IN 46218.)

3 DESCRIPTION OF THE STANDARD ELECTRONIC MODULES PROGRAM

. General This section will provide the program manager with a brief [illegible]ption of the organization, requirements, and documentation of the SEMP. The [illegible]ram manager can obtain a detailed description of SEM design and quality assurance requirements by referring to MIL-STD-1389 and MIL-M-28787 respectively.

3.2 Organization of the SEMP. The organization of the SEMP is comprised of the [illegible]lowing activities (see figure 1)

a Management Activity.

b Design Review Activity (DRA)

c Quality Assurance Activity (QAA).

d. Supporting Laboratory Activities.

The following is a brief description of the Government activities which function in these roles and of the responsibilities of each.

3.2.1 Responsibilities of the Management Activity. The Management Activity is responsible for the operation of the entire SEMP. For the Navy this function has been assigned to the Naval Electronic Systems Command under its charter for [c]entralization of electronics standardization efforts within the Navy and NAVMAT INSTRUCTION 4120.102 Specifically, these responsibilities are implemented by the Components Engineering and Program Management Branch (Code 8134), telephone (202) 692-8750 or AUTOVON 222-8750 These responsiblities are

a Establishment of SEMP objectives consistent with the Department of Defense (DoD) standardization requirements.

b. Organization, implementation, and control of the program necessary to meet DoD objectives.

c Organization and direction of SEMP laboratory activities.

d. Promotion of the SEMP within the DoD organization

e Sponsorship of SEM development activities.

f Coordination of SEMP with other Government organizations.

3.2.1.1 Responsibilities of the Design Review Activity. The Design Review Activity has as its primary responsibility the review and classification of each SEM proposed for development. This function is currently being performed by the Naval Avionics Center, Indianapolis, IN. The specific responsibilities of this activity are

a To review design approval requests (DAR) for all newly proposed SEM and classify them as to their potential use as SEMP standards.

b To assign SEMP key codes and specification numbers for new SEM designs.

c To perform special studies as directed by the SEMP Management Activity.

d. To provide technical coordination and assistance to SEM users.

e. To maintain the SEMP data bank and information retrieval system.

3.2.1.2 Responsibilities of the Quality Assurance Activity. The Quality Assurance Activity is primarily responsible for the MIL-M-28787 qualified products list (QPL). This QPL is currently maintained by the Naval Weapons Support Center, Crane, IN. The specific responsibilities of this activity are.

a. To establish and maintain SEMP quality assurance requirements.

b. To perform initial and periodic SEM qualification testing and vendors' quality program audits.

c. To perform correlation of SEM test equipment.

d. To review and approve SEM and SEM parts acquisition specifications.

e. To provide technical control over all module designs, piece parts, and documentation.

f. To perform failure analysis and compile SEM reliability data.

3.2.1.3 Responsibilities of the Supporting Laboratory Activities. Various laboratories within each of the services provide support to the Management Activity through their departmental custodians. One of the major support areas is for R & D. Laboratories such as Naval Ocean Systems Center (NOSC), Air Force Avionics Laboratory (AFAL), Army Electronic Techniques and Devices Laboratory (ET&DL), and others provide services, as may be required, to constantly broaden the SEMP application coverage for various categories of systems and systems' platforms. Their tasks have been concentrated in the following areas.

a. Systems analysis and applications.

b. Functional module concepts and development.

c. Advanced modular packaging concepts and development.

d. Technology assessment and applications.

3.3 SEMP implementation requirements. For the Navy, the Chief of Naval Material through NAVMAT INSTRUCTION 4120.102 and implementing instructions in NAVELEX and NAVSEA requires that SEM be used in all new developments and all substantial redesigns, where costs exceed one million dollars, unless it is shown to be technically or economically not feasible to do so. In these cases, it is required that a NAVMAT waiver be obtained through submission of a SEM notification form with supporting rationale and data attached. Acquisition plans shall address the use or nonuse of SEM.

3.4 SEMP documentation. The mechanical and environmental requirements for SEMP modules are given in specifications which describe the electrical, functional, and reliability requirements for each module type. These specifications are prepared in accordance with MIL-STD-1378. The specifications for SEMP modules are prepared by the original module developer for approval and control within the SEMP. They specify requirements for form, fit, and function rather than detailed design requirements. This documentation technique permits module vendors to produce modules without unnecessary restrictions on components and specific design details as long as the functional requirements of the specifications are met.

Though the details of design are left to the module developer and subsequent vendors, it is essential that interface standards and reliability requirements be observed, therefore, the basic mechanical configurations from which the designer may choose are set forth in MIL-STD-1389. This standard prescribes the design requirements which will enable modules to satisfy the quality assurance requirements specified in MIL-M-28787.

5.2.2 Mathematical representation of LCC model.

Total program LCC = Σ Module development cost (MDC) + Σ Module qualification cost (MQC) } See 5.3 + [No. of systems 1/ to be acquired] x [Life cycle module cost (LCMC) of a system of modules] (1)

LCMC = Acquisition cost of modules used per system (CSM)
+ Cost of initial spare modules per system (CIS)
+ Cost of replacement spare modules per system (CRS)
+ Cost of module repair per system (CMR)
+ Cost of pipe line assets per system (PA)
- Terminal value of modules per system (TV)

or,

$$LCMC = CSM + CIS + CRS + CMR + PA - TV \quad (2)$$

Terms in equation (2) are further defined by equations (3) through (8) and the definitions following equation (8).

$$CSM = \sum_{i=1}^{N_T} N_i \; C_{mi} \quad (3)$$

$$CIS = \sum_{i=1}^{N_T} N_{si} \; C_{mi} \quad (4)$$

$$CRS = \sum_{i=1}^{N_T} N_i \; \lambda_{mi} \; t_L \; C_{mi} \; (1-K_{Ri}) \quad (5)$$

$$CMR = \sum_{i=1}^{N_T} N_i \; \lambda_{mi} \; t_L \; C_{mi} \; K_{CORi} \; K_{Ri} \quad (6)$$

$$PA = \sum_{i=1}^{N_T} N_i \; \lambda_{mi} \; C_{mi} \left[(t_{DS} + t_{SR} + t_{RD}) \; (K_{GBi} + K_{Ri}) + t_{DS} \; (1-K_{Ri}) \right] \quad (7)$$

$$TV = \sum_{i=1}^{N_T} N_i \; C_{mi} \; K_{TVi} \left[1 + \frac{N_{si}}{N_i} + \lambda_{mi} \; (t_{DS} + t_{SR} + t_{RD}) \; (K_{GBi} + K_{Ri}) + \lambda_{mi} \; t_{DS} \; (1-K_{Ri}) \right] \quad (8)$$

where

N_T = Number of types of modules per system

i = Subscript for type i module

N_i = Number of modules of type i

λ_{mi} = Failures per hour per module of type i = $\lambda_{mii} \; K_{FRi}$

t_L = System life, hours

C_{mi} = Cost (dollars) per module of type i

λ_{mii} = Failures per hour per module type i predicted from the inherrent reliability of its parts

1/ The term system can be defined to mean equipment, subsystem, or system, as required

In addition, the SEMP makes available the following information and applications oriented documentation:

MIL-STD-1634 - Module Descriptions for the Standard Electronic Modules Program.
MIL-STD-1665 - Test Equipment for the Standard Electronic Modules Program.
TP-526 - SEM Program Microprocessor Applications Handbook.
TP-527 - SEM Program Synchro Converter Applications Handbook.
SEM System Application Report.
TP-528 - SEM Program Memory Applications Handbook.
TP-529 - SEM Program Thermal Applications Handbook.
TP-531 - In-Process Module Descriptions Handbook.
TP-532 - SEM Program Hardware Catalog.
SEM Program Module Listing.
SEM Notes Newsletter.

3.5 SEM characteristics. During the initial development phase of the SEMP, many modular packaging concepts were evaluated in order to select a concept that would provide the needed flexibility to accommodate present and future circuit technologies. This effort resulted in adopting a functional module concept in which the electronic function and mechanical interfaces were the controlling factors, rather than merely adopting a design for a specific mechanical hardware configuration. The following is a brief description of the pertinent characteristics of the SEM. For your convenience a brief but more detailed description of the module is contained in appendix C.

3.5.1 Electrical. The detail electrical characteristics and parameters are specified within the detail specification. However, standardized digital logic level interfaces, power supply voltages, and module contact pin assignments are controlled by the SEMP documentation.

3.5.2 Mechanical. The SEMP provides multiple module formats and sizes in a disciplined incremental growth approach to accommodate a variety of system packaging alternatives. The module packaging approach chosen is flexible and easily adaptable to many different component packages and interconnection schemes. Additional formats and size developments are under study and will be incorporated into the program upon proper definition and if there exists a justifiable need.

3.5.3 Environmental. The entire spectrum of environmental requirements for equipment used in shore, shipboard, airborne, and missile systems was investigated in an effort to establish common requirements for SEM. As a result, three classes were established, class I which is compatible with MIL-E-16400 for shipboard and shore (0° to 60°C); class II which is compatible with MIL-E-5400 and oriented for avionics (-55° to 85°C); and class III which incorporates radiation hardening requirements to the basic class II module category.

3.6 Quality assurance requirements. Because SEM must be interchangeable, regardless of. a. the manufacturer, b. the techniques used in their construction, or c. the systems in which they are used, stringent demands have been placed on quality assurance and performance testing to ensure such interchangeability. Each module design must meet quality assurance requirements for initial qualification, periodic qualification, and quality conformance testing. For detailed information on quality assurance requirements, reference should be made to MIL-M-28787.

New module designs are initially reviewed and tested at the SEMP-QAA to verify the adequacy of their design and specification. As a module type proceeds into production, the vendors must periodically submit samples from production lines to the SEMP-QAA for periodic qualification testing. This initial and periodic testing is necessary to ensure good basic design and to establish the manufacturer as a qualified vendor by confirming his capability for continuing to produce the module in conformance with SEMP requirements. Quality conformance tests are conducted at the vendor's facility to ensure the quality of the module.

In addition, each vendor's test equipment is correlated with test equipment at the SEMP-QAA. This ensures that each vendor is performing the required test correctly, and that all test equipment yields comparable results in order that module interchangeability can be maintained without requiring identical test setups.

3.7 Reliability requirements. The maximum failure rate for each module type is specified in the covering detail specification. Although the SEMP does not specify a single minimum mean-time-between-failure (MTBF), SEM are high-reliability components due to the stringent quality and qualification requirements imposed on designs and vendors This can be verified from fleet failure data compiled by the SEMP-QAA which has established that SEM have an average failure rate less than 0.05 failure per million hours.

Each detail specification specifies a predicted failure rate requirement. The SEMP-QAA consequently reviews each module vendor's specific design and component selection to ensure that this reliability requirement will be met.

3.8 Documentation requirements. All SEM must be documented with detail specifications prepared in accordance with MIL-STD-1378. These specifications are prepared by the module developer.

Specifications for SEM standard modules are functional in nature, specifying requirements for the module form, fit, and function rather than detailing the internal design. This documentation technique permits module vendors to produce the module with minimal restriction on design or components, as long as the functional requirements of the specification are satisfied. This functional documentation technique may be more costly than that of the commonly employed design disclosed format often used for SEMP special and candidate standard modules where all aspects of the design are specified, but will provide offsetting cost benefits in the long term because it

a. Permits module vendors to employ designs and component parts which may be more in tune with their facilities.

b. Permits cost savings through state-of-the-art advances and vendor innovation.

c. Facilitates a greater degree of competition.

d. Ensures that modules can be supported in the future without dependence upon a single technology or circuit design.

e. Requires less documentation maintenance.

Functional specifications are preferred for SEMP candidate standard modules for the above reasons, however, they are optional for SEMP special and candidate standard modules.

MIL-STD-1378 also specifies requirements for design disclosed documentation which is commonly used in documenting SEMP special and candidate standard modules.

3.9 Configuration management. The SEMP management activity is responsible for maintaining configuration management for all SEMP standard modules. They review all proposed revisions and coordinate with common module users to determine whether module interchangeability would be adversely affected. SEMP special module configuration management remains the responsibility of the developer (i.e., the sponsoring program office or acquisition office). SEMP candidate standard module configuration remains the responsibility of the developer until the time the module is fully developed as a SEMP standard. However, prior to that time any changes to the documentation, design of the module, or selection of components, must be identified to the SEMP-DRA.

4. BENEFITS GAINED THROUGH USE OF THE SEMP

4.1 General. The potential benefits that can be gained through the effective application of existing SEM are truly significant, and touch upon almost every facet of the system life cycle. Although the SEMP may not be the panacea for all electronics development programs, potential benefits certainly justify its careful consideration. Following is a brief discussion of such benefits.

4.2 Design benefits. Significant cost and time savings can be realized by the SEMP user through the effective use of existing SEM and established requirements for new module design and development efforts.

4.2.1 Existing module designs. The system contractor can greatly limit requirements for new electronic hardware design, development, and testing by use of existing SEM. This allows the system contractor to concentrate on system design, rather than having to expend major resources designing new functional modules.

4.2.2 Proven design requirements. By utilizing established SEMP design requirements for new module development, the contractor is immediately given design direction and requirements which have been proven in numerous system applications. This will eliminate the need for initiating costly module packaging studies and development programs, as well as for developing extensive reliability data.

4.2.3 Development of breadboard equipments. The use of existing SEM can assist the system contractor in developing equipment "breadboard" models. The Quality Assurance Activity has a limited inventory of commonly used standard modules, module piece parts, and associated mounting/interconnection hardware. These items are made available to system developers at prices equal to Government cost and can be employed to construct system "breadboard" models. Since the items are production hardware, "breadboard" models are virtually preproduction models, thus possibly eliminating an entire step in the equipment development cycle.

4.2.4 Related SEMP design aids. The SEMP provides module users with various documents which will assist in the module and system design process. Such aids range from documents which will provide new module design philosophy and system application information to brief module abstracts which enable engineers to quickly review (or assess) the function and capability of each standard module. The following is a listing of such design aid documents:

MIL-M-28787	MIL-STD-1634
MIL-STD-1378	MIL-STD-1665
MIL-STD-1389	

4.3 Production benefits. System production costs and lead times may be reduced through the use of existing SEM.

4.3.1 Existing documentation. The use of existing SEM documentation eliminates the requirement for having to prepare such documentation, thereby permitting its immediate use for acquisition.

4.3.2 Existing sources. The use of existing SEM benefits the user in that there are existing qualified module production sources, and, in most cases, multiple production sources for such modules. This eliminates the need for having to develop qualified vendors and, consequently, reduces the time required for delivery.

4.3.3 Competitive prices. The acquisition of multiple-sourced SEM from the existing industry base by the system contractor will result in more competitive prices. This fact has been conclusively proven. This can be attributed to the direct result of competition. As other systems required similar module functions, more module vendors became qualified to produce them, and through a combination of competition and higher production volumes, the module prices decreased considerably.

4.3.4 Shorter lead times. The acquisition of modules from existing sources results in considerably shorter lead times due to:

a. Currently active module production, thereby eliminating time consuming and costly startup.

b. Familiarization of module producers with the requirements of the SEMP.

c. The availability of tooling.

4.4 Maintenance benefits. The use of SEM improves the maintenance posture of equipments due to modular construction and discard upon failure maintenance concept.

4.4.1 Lower functional level of spares. Being able to replace modular elements of a functional subassembly rather than the subassembly itself is usually accepted to be the more cost effective maintenance practice.

4.4.2 Reduction in maintenance requirements. Through the use of electronic modules designed for discard upon failure, cost savings are realized by not requiring costly repair facilities, repair and test equipment, training aids, high personnel skill levels, and the many other related items required to support such an effort.

4.5 Logistics benefits. The logistical support of electronic systems has historically presented military logisticians with many difficulties, and is considered by many to be the largest single factor in equipment life cycle cost considerations. The SEMP has been extremely conscious of this factor and has established many of its requirements based upon such considerations. The possible reduction in material management costs associated with introducing and maintaining the present piece part inventory could be one such benefit.

4.5.1 Not technology limited. The design of electronics around a single technology or specific devices has, in the past, caused serious difficulties in the logistic support of equipments. This situation occurs when electronic hardware is designed and documented with design disclosed specifications, where each part, electrical and mechanical, is specifically identified and detailed. This documentation method results in a permanent dependence on a specific circuit technology or part, making it difficult or even impossible to obtain replacement parts in the future, especially after industry emphasis has shifted to newer technology devices. Such a situation means that either special production sources have to be established to supply the particular part, or that a redesign must be initiated to accommodate available substitutes. In either case, the cost to provide spares or replacement parts is exorbitant. By requiring the preparation of functional specifications for SEM, the SEMP defines the specific module form, fit, and function rather than its component parts. By this technique, interchangeable modules can be obtained without costly documentation changes.

4.5.2 Nonproprietary acquisition. Many systems have been designed and fabricated of electronic "black box" packages which were either of a proprietary design, or simply a one-of-a-kind design from a single source. In either case, competitive acquisition from the initial development phase and the system support phase was not possible, or, at best, was not cost effective. The SEMP mitigates this problem by limiting proprietary designs to areas which will not inhibit competitive acquisition and by encouraging multiple sources of supply.

4.5.3 Intersystem commonality. The task of logistically supporting SEM mechanized systems upon a common platform is greatly simplified by being able to share such things as common module spares inventory, test equipment, test software, documentation, and so forth.

5 LIFE CYCLE COST ANALYSIS

5.1 Introduction. The justification for using SEM as described in section 4 is extensive, varied, and ultimately can be condensed into a single factor. Life cycle cost savings. Life cycle cost/costing (LCC) are commonly used terms related to analytical procedures employed in the performance of defense equipment comparative economic evaluations. Unfortunately, the analytical aspects of the concept of minimizing the total cost of ownership are all too often disregarded in favor of the more visible and immediate objective of concentrating on either initial acquisition cost or maintenance and logistics support cost rather than determining the proper balance between essential levels of equipment performance and minimum total life cycle cost. In the past, there have been two primary reasons for ignoring life cycle costs in a contract award decision:

a. Contracting officers experienced difficulty in defending awards made to other than the low bidder. This factor, together with the lack of explicit endorsement at that time of life cycle costing by the DoD, caused great reluctance to employ economic award criteria other than initial price. Now that more guidance is available and endorsed at the highest levels of DoD technical and acquisition management, such reluctance to life cycle costing should be diminished.

b. The existing multiplicity of appropriations and compartmentalization of functional responsibilities are not conducive to life cycle cost acquisition. Usually, equipments are designed and acquired under one appropriation while logistics functions are supported by another.

The importance of assessing total ownership cost is obscured and personnel specializing in these different functions are usually separated organizationally. As a result, they have a natural tendency to seek maximum results in their own areas and not consider the effects of their actions on other functions. Life cycle costing, therefore, will continue to require a greater degree of cooperative effort in order that the DoD can derive full benefit from standardization.

5.2 Conducting a life cycle cost analysis. The costing methodology contained herein is directed toward those estimating procedures that the technically oriented program manager/engineer can readily and systematically apply to determine the economic feasibility of employing SEM. Emphasis is placed on the differences between SEM and non-SEM in the context of an end item equipment configuration and in the identification of the elements of cost within a model. Consequently, industrial vendors, major contractors for DoD electronic systems, and cognizant DoD laboratories generally agree on the formatting and nomenclature of costing which is presented herein.

5.2.1 LCC model. This section presents a model for computing the relative life cycle cost of electronic equipment utilizing SEM or non-SEM. A reasonable cost trade-off decision can then be made as to which mechanization, SEM or non-SEM, should be used in a particular application.

The LCC model presented is not intended to take the place of a more exact and detailed cost analysis when such is required or practical. The model presented, however, can be used effectively in the early screening of possible alternatives to eliminate noncompetitive modular packaging techniques.

This LCC model is neither complete nor exact, thereby avoiding unnecessary tedium of inconsequential cost differences. As changing values and additional data become available, items can be added or deleted in the cost model with relative ease. Consequently, each systems command and, in many cases, each program office has different requirements which affect life cycle cost in a manner which may require adjustment to the LCC model given in this section.

As given, the LCC model includes only the electronic module costs, the interconnecting module back panel, support structure, card cages, enclosure, etc., are not included because they, in all probability, will present a one-to-one correspondence. The user, however, can add these costs or estimations to the model as needed.

5.2.2 Mathematical representation of LCC model.

Total program LCC = Σ Module development cost (MDC) } See 5.3
+ Σ Module qualification cost (MQC) }
+ [No. of systems 1/ to be acquired] x [Life cycle module cost (LCMC) of a system of modules] (1)

LCMC = Acquisition cost of modules used per system (CSM)
+ Cost of initial spare modules per system (CIS)
+ Cost of replacement spare modules per system (CRS)
+ Cost of module repair per system (CMR)
+ Cost of pipe line assets per system (PA)
- Terminal value of modules per system (TV)

or,

$$LCMC = CSM + CIS + CRS + CMR + PA - TV \tag{2}$$

Terms in equation (2) are further defined by equations (3) through (8) and the definitions following equation (8).

$$CSM = \sum_{i=1}^{N_T} N_i \; C_{mi} \tag{3}$$

$$CIS = \sum_{i=1}^{N_T} N_{si} \; C_{mi} \tag{4}$$

$$CRS = \sum_{i=1}^{N_T} N_i \; \lambda_{mi} \; t_L \; C_{mi} \; (1-K_{Ri}) \tag{5}$$

$$CMR = \sum_{i=1}^{N_T} N_i \; \lambda_{mi} \; t_L \; C_{mi} \; K_{LORi} \; K_{Ri} \tag{6}$$

$$PA = \sum_{i=1}^{N_T} N_i \; \lambda_{mi} \; C_{mi} \left[(t_{DS} + t_{SR} + t_{RD}) \; (K_{GBi} + K_{Ri}) + t_{DS} \; (1-K_{Ri}) \right] \tag{7}$$

$$TV = \sum_{i=1}^{N_T} N_i \; C_{mi} \; K_{TVi} \left[1 + \frac{N_{si}}{N_i} + \lambda_{mi} \; (t_{DS} + t_{SR} + t_{RD}) \; (K_{GBi} + K_{Ri}) + \lambda_{mi} \; t_{DS} \; (1-K_{Ri}) \right] \tag{8}$$

where

N_T = Number of types of modules per system

i = Subscript for type i module

N_i = Number of modules of type i

λ_{mi} = Failures per hour per module of type i = $\lambda_{mii} \; K_{FRi}$

t_L = System life, hours

C_{mi} = Cost (dollars) per module of type i

λ_{mii} = Failures per hour per module type i predicted from the inherrent reliability of its parts

1/ The term system can be defined to mean equipment, subsystem, or system, as required

k_{FRi} = Failure rate adjustment factor for ratio of operational failure rate to inherent failure rate of module type i

N_{si} = Number of initial spares of module type i required per system

K_{TVi} = Ratio of terminal value per module of type i to initial cost of module

K_{Ri} = Ratio of failed repairable modules of type i which can be economically repaired to failed repairable modules of type i

K_{Ri} = 0, for a nonrepairable module of type i

K_{CORi} = Ratio of cost of repair per failed module of type i to cost of module

t_{DS} = Pipe line time in hours from depot to system

t_{SR} = Pipe line time in hours from system to repair facility

t_{RD} = Pipe line time in hours from repair facility to depot

K_{GBi} = Ratio of number of returned good modules to number of failed modules of type i

Equation (2) may be written as follows using equations (3) through (8).

$$LCMC = \sum_{i=1}^{N_T} N_i C_{mi} (1 - K_{TVi}) \left\{ 1 + \frac{N_{si}}{N_i} + t_L \lambda_{mi} \left[\frac{1 + K_{Ri} (K_{CORi} - 1)}{1 - K_{TVi}} + \frac{(t_{DS} + t_{SR} + t_{RD}) (K_{GBi} + K_{Ri}) + t_{DS} (1 - K_{Ri})}{t_L} \right] \right\} \quad (9)$$

<u>Special cases</u>:

1. If all modules are determined to be economically nonrepairable (K_{Ri} = 0) (as are most SEM)

$$LCMC = \sum_{i=1}^{N_T} N_i C_{mi} (1 - K_{TVi}) \left\{ 1 + \frac{N_{si}}{N_i} + \frac{t_L \lambda_{mi}}{1 - K_{TVi}} + \lambda_{mi} \left[K_{GBi} (t_{DS} + t_{SR} + t_{RD}) + t_{DS} \right] \right\} \quad (10)$$

2. For a very simple model assume:

All modules are same cost ($C_{mi} = C_M$)

All modules are nonrepairable (K_{Ri} = 0)

All modules have the same failure rate ($\lambda_{mi} = \lambda_m$)

There are two spares per type per system

$\left(\sum_{i=1}^{N_T} N_{si} = 2N_T \right)$. Also, $t_{DS} = t_{DR} = t_{RD}$

$$LCMC = N_M C_M (1 - K_{TV}) \left[1 + \frac{2N_T}{N_M} + \frac{t_L \lambda_m}{1 - K_{TV}} + \lambda_m t_{DS} (1 + 3K_{GB}) \right] \quad (11)$$

where:

$$\sum_{i=1}^{N_T} N_i = N_1 + N_2 + \ldots + N_T = N_M$$

5.2.2.1 SEM costing model. In order to develop basic SEM costing data that can be used in a comparative system analysis, it is recommended that the program manager employ the costing data presented in table I. Whereas this model provides for a comparison between a system employing SEM, and another comparable system not employing SEM, there may be instances where the reader wishes to consider the use of SEM in only a portion of a system. In that case, the procedure would be to limit the comparison to the consideration of SEM versus non-SEM implementation of the subsystem under study. The cost associated for these elements have been derived from actual SEM acquisitions, using the SEMP module MIL-M-28787/6, a (3) 4-bit binary counter, as the baseline for such cost. This module cost data can reasonably be expected to be representative for typical 1A size SEM cost estimates.

$C_{m1} = (MFC_1)\ 1.35$ 2/

$MFC_1 = MPP_1 + PCB_1 + EPP_1 + AH_1 + MT_1$

where

MFC = Module factory cost

MPP = Mechanical piece parts cost

PCB = Printed circuit board cost

EPP = Electrical piece parts cost. This is the cost of the integrated circuit, transistors, resistors, capacitors, etc

AH = Assembly and handling cost

MT = Module test

5.2.3 Costing procedure. The steps in performing a life cycle cost analysis are as follows

a. System definition. Define the functional parts of the system, number of systems to be acquired, and system life (t_L) and maintenance and ILS philosophy

b. Preliminary functional design. Define the functions in enough detail so that the design can be reasonably partitioned into SEM as an initial baseline configuration. SEM are selected as the reference point because of the existence of many SEM and their related known costs.

c. SEM system module definition.

(1) Determine the number of SEM types and quantities.

(2) Determine the number of new SEM types and quantities.

(3) Determine the number of special SEM types and quantity of each that are planned to be repaired.

d Non-SEM system module definition. Determine the number of module types and quantity required If a detailed knowledge of the non-SEM system does not exist, the following relationships, based on actual SEM and non-SEM systems, can be applied to the data determined in step c. to arrive at a reasonable estimate as to the number of non-SEM types and quantity required.

Per system basis	SEM	Non-SEM
Total number of modules	3	1.0
Total number of types	1	1.5

2/ Sell price or module cost is defined as the module factory cost plus general administrative expense and negotiated fee. A conversion factor of 135 percent applied to the module factory cost closely approximates the module sell price or module cost

e. Module reliability. Determine the reliability figures for existing SEM. This can be obtained from the various module functional specifications and actual field failure data obtainable from the SEMP-QAA. For new SEM, the reliability can be estimated by comparison with existing SEM, relating their relative complexities. For the non-SEM system, if details are not known, the following relationship, based on a comparison of SEM and non-SEM module size, density, and complexity, can be used.

Per integrated circuit basis	SEM	Non-SEM
Reliability	5	1

This relationship simply states that, because of the reduced size, density, and complexity of SEM combined with very stringent quality assurance requirements, SEM are on an average five times more reliable than non-SEM counterparts. MIL-HDBK-217 may also be used as a method of reliability prediction of non-SEM.

f. Module cost. Determine the cost of each module type, SEM and non-SEM. Table I contains the cost elements associated with a typical SEM. The cost associated with each element in table I has been derived from actual manufacturing data for the MIL-M-28787/6 module. The following relationship enables the user to arrive at a reasonable average for non-SEM cost.

Per integrated circuit basis	SEM	Non-SEM
Cost	1	3

Again, this relationship is based on data derived from previously developed SEM and non-SEM systems. It must be remembered that these are just averages and were determined essentially by the fact that the non-SEM module is three times as complex (number of components).

g. Develop an initial sparing philosophy. This philosophy should be based on the planned maintenance and ILS for the system.

h. Module repairability and cost. Determine the repairability of non-SEM module types and typical costs for the repair and return function. Some SEMP special modules as well as most non-SEMP types can be expected to be repaired. These determinations, however, are subject to whatever cost versus discard criteria are to be employed Level of repair analysis should be made to determine repairability and repair cost whenever sufficient information is available.

i. Pipeline elements. Determine the module cycle time through the replenishment loop (platform via repair facility via depot via platform) which constitutes a time related cost as does the ratio of good to bad modules introduced into the cycle. These factors, if identifiable, contribute to determining the pipeline assets and terminal value of system modules. The elements to be determined are t_{DS}, t_{SR}, t_{RD}, and K_{GB}.

j. Terminal value ratio. Determine the terminal value ratio which is the end of life value of a module to its initial cost. Since the likelihood of using non-SEMP modules in other than the original system application is nil, and since the likelihood of using SEM in other system applications is relatively high, experience has shown that TV for non-SEM usually equals zero, whereas, TV for SEM is usually equal to 25 percent of the original module cost per system

5.2 3.1 Life cycle costing example See appendix B for an example of the use of the life cycle cost analysis model.

TABLE I. Production cost model for SEM. 1/

Baseline cost 2/	Number acquired	Years in production 3/	Recurring cost model					Factory cost	Sell price 135% 4/
			Mechanized piece parts	PC board	Integrated circuitry	Assembly and handling	Unit test		
1.	0-5	3rd	$3.25	$1.50	$15.00	$85.86	$5.50	$111.11	$150.00
2.	5-50	3rd	3.00	1.25	12.00	53.82	4.00	74.07	100.00
3.	50-200	3rd	2.75	1.15	11.50	37.15	3.00	55.55	75.00
4.	200-500	3rd	2.75	1.00	9.60	20.00	2.00	35.35	47.72
5.	500-1000	3rd	2.00	0.75	8.40	14.00	1.50	26.65	35.98
6.	1,000(+)	3rd	1.75	0.50	8.00	12.20	1.25	23.70	32.00

1/ All values given as typical are based on available cost data at the time of publication of this handbook. More recent data should, of course, be used whenever it is available.

2/ Any well defined module cost may be used as a baseline cost. The MIL-M-28787/6 module is used in this particular instance.

3/ Assumes 3rd year in manufacture as an industry norm where differences in time in manufacture impacts on integrated circuitry and assembly cost.

4/ Sell price is defined as factory cost plus general and administrative expenses and negotiated fee. A conversion factor of 135 percent applied to factory cost closely approximates sell price.

5.3 Module development and qualification cost. Module development costs are one-time or nonrecurring program costs that are incurred at various stages in the development of new modules for a program. Table II contains a breakdown of these costs as they relate to a SEMP standard, SEMP special, or non-SEMP module.

Qualification costs are also one-time costs to a program for new modules. On an average, the cost is $3.8 K per module type for initial qualification. This cost is incurred when the module is tested to insure that it is electrically designed and mechanically fabricated to meet prescribed military standards. Correlation expenses, however, are recurring costs for SEMP vendors as are costs for performing periodic qualification testing (see 6.5).

TABLE II. Development cost of a new digital module.

	SEM standard	SEM special	Non-SEM
Vendor's cost:			
Module design	$ 4.0 K	$ 4.0 K	$ 7.0 K
Breadboard and test	2.0	2.0	2.0
Specification and data preparation	12.0	10.0	8.0
Build documentation	1.5	1.5	2.0
Build design qualification modules	2.0	2.0	2.5
Production startup	5.0	4.0	4.0
Subtotal	$26.5 K	$23.5 K	$25.5 K
SEMP-QAA cost:			
Correlation data	2.0 K	---	---
Correlate vendor	1.4	---	---
Initial qualification	3.8	---	---
Design evaluation	---	4.5	5.0
Subtotal	$ 7.2 K	$ 4.5 K	$ 5.0 K
Total	$33.7 K	$28.0 K	$30.5 K

6. FUNDING CONSIDERATIONS FOR THE STANDARD ELECTRONIC MODULES PROGRAM

6.1 Introduction. The program manager should realize that the employment of SEM may require funding for new module qualification testing and related services. It is the program manager's responsibility to directly fund the appropriate SEMP activity for required services in support of the SEMP system requirement. This section does not attempt to provide a detailed cost analysis of each element associated with the use of SEM in a particular system, but it does identify those cost elements which should be allocated for supporting the program manager in implementing normal SEMP quality assurance requirements. Also identified are cost elements which may be required if particular SEMP related services are desired by the program manager from the SEMP activities for other than the qualification of new module design. The SEMP has established a category of modules called SEMP candidate standards. This category permits the program manager to realize some of the benefits of SEMP standard modules, but defers the cost of development until no later than 2 years prior to initiation of the equipment production phase. Prior to that time the program manager should include the required funding in his program planning documents, or arrange with the SEMP management activity to ensure that adequate funding will be available to cover these costs in a timely fashion. The program manager is encouraged to budget for full development and qualification of candidate standard modules during the development phase. The disadvantages of deferring these efforts are: increased documentation cost, discourages vendor price competition, reduces design flexibility, eliminates competitive vendor innovation, increases interchangeability risks (designers not available at the time the functional specifications are written), discourages use by other programs, increases quality risks (no qualification or correlation), etc.

The cost elements described herein are mainly those which are necessary to control and monitor the introduction of new SEMP standard module designs.

It should also be noted that there may be situations where the funding of SEMP quality assurance requirements may not be necessary. Such would be the case where a system contractor exclusively used existing SEM currently manufactured by qualified sources. This, obviously, is an optimum situation for it is dependent upon many systems dependent variables and constraints. As the SEMP library of functions expands to offer more comprehensive coverage, this situation will become more probable.

6.2 SEMP Quality Assurance Activity funding. The SEMP-QAA operated by the Naval Weapons Support Center, Crane, Indiana, is the only SEMP activity that will require separate funding on the part of the program manager for normal SEM services. This funding will be required for the performance of the following minimum essential requirements for a SEM implemented system

a Initial qualification of new SEM.

b. Periodic qualification of all SEM.

c Tester correlation of SEM test systems

6.2 1 Related SEM services Depending on the particular situation and requirements of the program manager, the scope of services available can be vastly expanded. Such services, however, are in addition to the normal qualification requirements of the SEMP and are at the prerogative of the program manager. The following is a listing of some of the related services which have been performed by the SEMP-QAA

a. Providing qualification and/or tester correlation of all or selected SEMP special modules

b Providing technical assistance during the review and evaluation of contractor proposals and during the program design review periods

c Performing failure analyses

d Compiling and analyzing module reliability data

e [illegible] maintenance [illegible] [illegible] for failed modules

f. Performing special environmental testing (radiation, etc.).

g. Performing component testing/qualification

h. Developing, controlling, and maintaining technical documentation (other than detail specifications for standard modules).

i. Performing SEM feasibility studies.

j. Reviewing new SEM specifications.

k. Performing new technology evaluations.

Inquiries should be addressed to:

Commanding Officer
Naval Weapons Support Center
Crane, IN 47522
ATTN: Code 6034
Telephone: (812) 854-1854
AUTOVON: 482-1854

6.3 SEMP Design Review Activity services. Certain services provided by the SEMP-DRA (Naval Avionics Center, Indianapolis, Indiana) are incurred as an administrative expense and are funded by the SEMP Management Activity. Services provided by the SEMP-DRA without cost to the program manager are.

a. Initial design review of newly proposed SEM and their classification as being either standard or special modules.

b. Assignment of SEMP key codes to all SEM.

c. Assignment of specification numbers to all SEM standards (detail specifications)

6.3.1 Related services of the SEMP-DRA. In addition to the services described in 6.3, the SEMP-DRA can provide services that support the program manager through all phases of the system development life cycle. Typical services that are available are:

a. Providing technical assistance during the review and evaluation of contractor proposals and during program design reviews

b Providing electrical, mechanical and thermal design assistance to system developer relative to SEM implementation.

c. Providing design and production qualification services for back panel interconnection assemblies.

d. Providing review and evaluation of contractor generated detail specifications.

e. Conducting system application studies relative to state-of-the-art technology electronic functions.

f. Performing design, development, and documentation of modules which utilize state-of-the-art technology.

g. Providing technical consulation in resolving problems that arise in the manufacture and acquisition of SEMP modules

h. Providing technical assistance in partitioning systems to optimize the use of SEM.

Inquiries should be addressed to

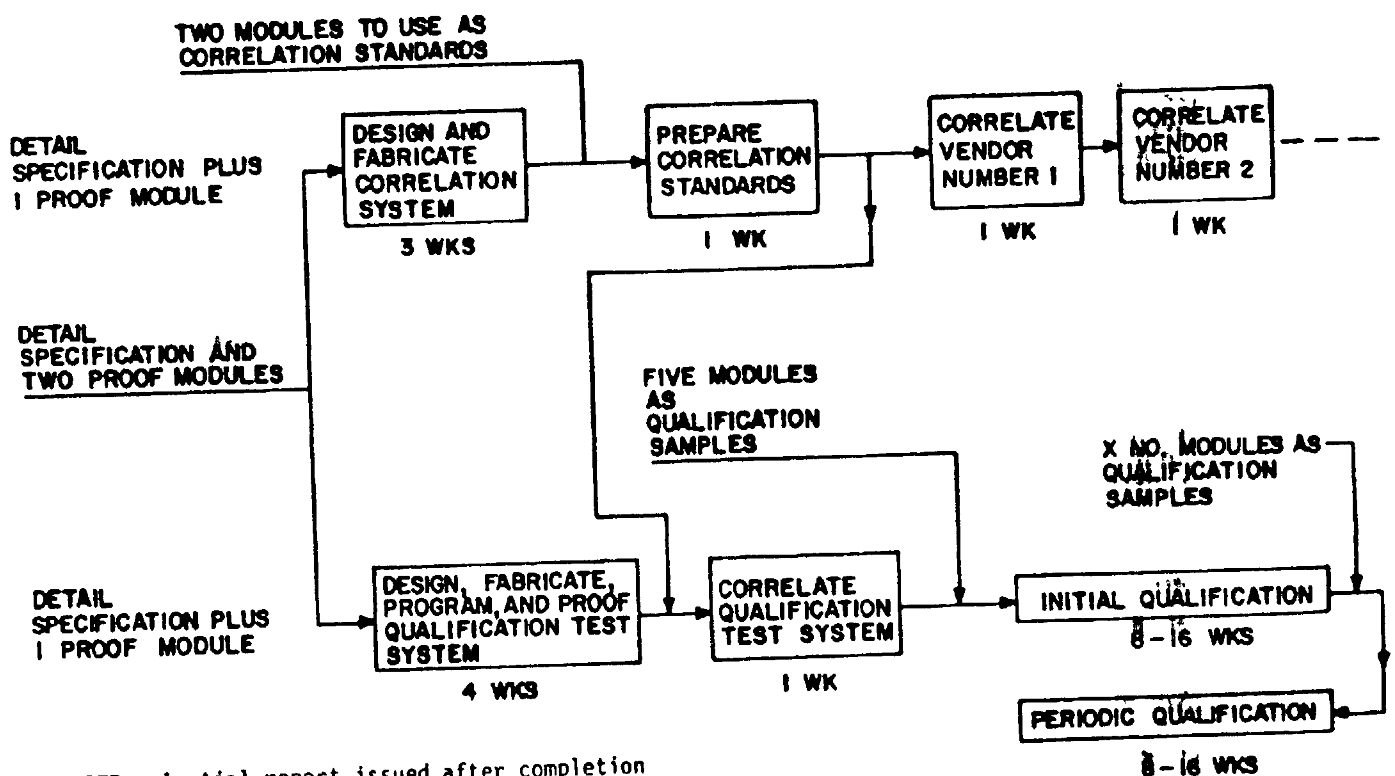
Commanding Officer
Naval Avionics Center
6000 E. 21st Street
Indianapolis, IN 46218
ATTN. Code D965
Telephone: (317) 353-3807
AUTOVON: 724-3807

6.4 Schedule for funding. The program manager should plan well in advance to establish a funding relationship with the SEMP-QAA for necessary quality assurance requirements. The program manager, however, will not be able to accurately determine any firm requirement until new module requirements have been established and classified by the SEMP-DRA. There is normally a time span between system contractor selection and the time when new SEM prototypes and specifications are ready for submission for initial qualification. This duration will vary according to the particular circumstances, but, from past experience, 6 to 9 months appears to be average for a normal design effort. Within this time frame, preferably in the earliest portion, the program manager should contract with the SEMP-QAA.

6.5 Typical costs for SEMP requirements. The cost of performing the basic qualification requirements at the SEMP-QAA are, for the most part, dependent upon the requirements of the specific module design The program manager, therefore, should provide the SEMP-QAA with all relevant information about the system contractor's proposed SEM implementation as early in the system acquisition cycle as possible. Upon review of such information, the SEMP-QAA will be capable of accurately estimating the funding that will be needed.

In order that the program manager can develop an understanding of such SEMP services, figure 2 depicts the qualification and correlation procedure for a new SEM, noting anticipated performance times for each milestone. The following presents average costs for each stage in the qualification process and should be reconfirmed by the SEMP-QAA prior to use for planning.

Design and fabricate correlation system (includes preparing correlation standards) - - - - - - - - -	$4,400
Correlate vendor -	$1,400/attempt
Design, fabricate, program, and proof qualification test system (includes correlation of system) - - - - - - - -	$7,400
Perform initial qualification testing- - - - - - - - - - - -	$3,800
Perform periodic qualification testing - - - - - - - - - - -	$2,700



NOTE Initial report issued after completion of operating temperature tests, or approximately 3 weeks after initiation of tests.

FIGURE 2 Module qualification and correlation flow for new standard modules

7. PREPARATION AND EVALUATION OF SEMP ACQUISITION DOCUMENTS

7.1 Introduction. The program manager, upon determining the desirability of SEM and design requirements for a particular system application, must then implement such a decision by placing SEM requirements within the appropriate contract planning documents. This section addresses the relevant factors which must be considered for SEM implementation within the following documents.

a. Technical development plan (TDP).

b. Request for proposal/quotation (RFP/RFQ).

c. Contract specification.

These documents do not exhaust the list of documents which should contain requirements and guidelines for the development, acquisition, and management of SEM and associated products and services. These are, however, typical documents prepared by program managers between the concept formulation and concept definition phases in a large system's life cycle. Keying from the broad guidelines in this section, the program manager should have sufficient information for preparing similar types of planning documents.

This section offers the program manager guidelines for the review and evaluation of SEM configured proposals, as well as guidance for transforming such proposals into definitive requirements for a contract specification.

7.2 Specifying SEM requirements.

7.2.1 SEM specification within technical development plans. The program manager should state his intention to use SEMP modules and design requirements as early in the program planning phase as possible. Such statements would be appropriate during the preparation of the TDP and should aid in the approval of the TDP by demonstrating the following

a. Positive response to the DoD objective for equipment standardization and life cycle cost consideration.

b. High confidence level in the system hardware mechanization method by using tried and proven SEMP modules and design requirements.

c. Sensitivity for the logistics costs for system development, a factor which all too often exceeds initial system acquisition cost.

d. Credible system funding estimates using SEMP cost data from many previous SEM system applications.

A statement to the effect that SEMP modules and design requirements will be considered in system implementation should be prepared for inclusion within the TDP. The place for such a declaration would be within section 4, "Standardization", and could be phrased

> "4.X Electronic hardware standardization. In order that the system's development and logistics costs can be minimized over its operational life cycle the requirements of the Standard Electronic Modules Program (SEMP) as described in MIL-STD-1378 are to be employed."

7.2.2 SEM specification within request for proposals/quotations. When preparing material for an RFP/RFQ, it is extremely important that the program manager be explicit when specifying the requirements for SEMP implementation. Vague statements concerning requirements could be as harmful to the acquisition process as no reference at all. MIL-STD-1378 has been prepared to provide a uniform and complete method for SEM implementation and optimization. It has been prepared expressly for use within the RFP/RFQ and contract document and will automatically invoke all appropriate SEM requirements and specifications by reference within the RFP/RFQ

> "Equipment electronic circuitry requirements shall be satisfied in accordance with the requirements of MIL-STD-1378, Requirements for Employing Standard Electronic Modules."

a. The object is to provide the equipment contractor with specific direction concerning module implementation and design requirements from initial proposal preparation to program completion. Specifically, MIL-STD-1378 establishes the requirements for the following.

   (1) Provides an order of priority for implementing SEMP modules and new module designs.

   (2) Establishes design requirements for new SEMP modules.

   (3) Provides documentation requirements (functionally specified or design disclosed) for new SEMP modules.

   (4) Provides quality assurance requirements for new SEMP modules.

   (5) Establishes procedures for controlling revisions to SEM.

b. In addition to the basic specification for SEM use, the RFP/RFQ should also address several other related items as follows.

   (1) A definition of the extent to which SEM are to be implemented, including the identification of all allowable deviations.

   (2) The identification of desired documentation category for SEMP special and candidate standard modules.

   (3) The identification of desired quality assurance requirements for SEMP special and candidate standard modules.

   (4) The identification of the desired technical, cost, and schedule information relative to the proposed SEM implementation.

   (5) A statement of evaluation criteria for SEM implementation proposals.

   (6) A clarification of the contractor's responsibilities for implementing SEM requirements relative to funding, schedules, and procedures.

It is imperative that items b.(2) and b.(3) above be addressed for SEMP special and candidate standard modules for MIL-STD-1378 requires that a decision be made by the program manager between various documentation methods, as well as requiring "unless otherwise specified", that all SEMP special and candidate standard modules be fully qualified.

7.2.2.1 Deviation to SEM requirement. In the event that the requirements for exceptions and deviations to the use of SEM as contained within MIL-STD-1378 are inappropriate, the RFP/RFQ should clearly state the scope or extent of SEM implementation that is desired within the system. This eventuality may arise because off-the-shelf equipment is available or another mechanization is more appropriate for a portion of the design. Also, if dictated by system development constraints, documentation and qualification of SEMP candidate standards (see MIL-STD-1378, section 5) may be deferred until completion of the development phase (i.e, prior to production).

7.2.2.2 Extent of SEM specification. The RFP/RFQ should identify the extent of implementation of SEM for a particular system application. If its use is desired to be all inclusive, the work statement should contain a requirement as in 7.2.2. On the other hand, where certain portions of a system are to be implemented with another electronics mechanization, such deviation should be clearly stated. Such may be the case where either off-the-shelf equipment may be available, or another mechanization may be more appropriate for a portion of the system.

It is recommended that the program manager establish definite requirements for the scope of SEM specification rather than leave certain areas of implementation to the option of the contractor. By this consistent policy, the task of reviewing and evaluating the various contractor proposals will be easier because they can be rated on a one-to-one basis. If the program manager wishes to grant such an option to the contractor, he should require that adequate justification be presented for any deviation requested. It should be noted that the fact that a SEM mechanization may not result in an "optimum" configuration should not be valid technical justification for exception to its use unless justified in the context of total life cycle cost and utility.

7.2.2.3 SEMP special and candidate standard module documentation requirements. The requirements of MIL-STD-1378 specify that SEMP special modules shall be documented with either functional specifications or design disclosed specifications as dictated by the appendices to MIL-STD-1378. It is incumbent upon the program manager to make this determination and it should be accomplished within the RFP/RFQ or work statement. If the program manager wishes to have all modules (SEMP standards, candidate standards, and specials) documented to the same requirements (functional specifications), it must be stated by the use of a statement such as the following

> "All SEMP modules are to be documented in accordance with MIL-STD-1378, appendix A, military specifications in accordance with MIL-STD-961."

In the past, most SEM users have required that a design disclosed documentation format be employed to document special and candidate standard modules, since their development is restricted by either program constraints in the development phase, or probable low system population. If the design disclosed format is desired for special and candidate standard modules, the RFP/RFQ work statement should then state.

> "All SEMP special and candidate standard modules are to be documented in accordance with MIL-STD-1378, appendix D, type C2b specifications."

It should be noted that although the SEMP recommends that special modules employ documentation requirements in accordance with MIL-STD-1378, the program manager may exercise an option for deviation if so inclined. However, he should be aware of serious problems which might arise by not specifying an adequate documentation requirement. He is urged to employ as a very minimum requirement DOD-D-1000, level 2, for documenting such modules.

7.2.2.4 SEMP special and candidate standard module qualification requirements. The requirements of MIL-STD-1378 state in effect that SEMP special and candidate standard modules shall be qualified to SEMP requirements unless otherwise specified. Although such qualification testing would undoubtedly result in added system reliability, the lack of available funds by program managers has often prevented this level of testing. Rather than eliminating module testing requirements entirely, some modified substitute is strongly recommended.

Many program managers in the past have developed separate quality assurance programs for special and candidate standard modules to suit their budget. It is an accepted fact that testing and corrective actions are two of the prime assurances of reliability and limited testing is better than none. It is therefore recommended that the SEMP-QAA be contacted for their assistance in the establishment of module test programs. If full SEMP qualification requirements cannot be supported, the program manager should clearly state an alternate program within the RFP/RFQ. Although the RFP/RFQ work statement need not define the exact details of such a module testing program, it should identify the responsibilities and requirements of the particular systems contractor. Factors such as the number of modules required for testing, where testing is to be accomplished and by whom, procedure for resubmittal upon failure, etc., should be clearly defined in order that accurate costing and scheduling can be determined.

An example of an appropriate statement of work relative to SEMP special and candidate standard module testing could read as follows

> "All new SEM classified as specials or candidate standards by the SEMP Design Review Activity shall be qualified to a testing program as follows. (Define particular requirements.)"

7.2.2.5 Information required within the proposal. To enable the program manager to establish a comparative basis for evaluating proposals, contractors should be required to provide certain information relative to the proposed SEM implementation as specified within the RFP/RFQ. The degree of information required will likely vary from program to program because of differences in contract type, schedules, program complexity, etc., and therefore, should be determined by each program manager prior to the preparation of the RFP/RFQ.

The kind of information which should be considered is that which can be used to evaluate the performance of the contractor in his utilization of SEMP modules and design requirements. The following is a listing of different categories of relevant information which should, if possible, be required by specification within the RFP/RFQ:

a. Identify total number of SEM types required.

b. Identify total number of existing SEM types required.

c. Identify total number of SEM per system required.

d. Identify total number of SEM of each module type.

e. Provide justification for new SEM types.

f. Provide cost data for proposed SEM implementation.

g. Provide jusitification for use of other electronic hardware mechanization concept (if permitted).

h. Provide descriptive information on new SEMP module designs proposed.

i. Identify valid areas of risk which might arise as a result of the use of SEM.

j. Provide an implementation plan for accomplishing events such as submission of design approval requests, initial qualification, correlation, and other SEMP milestones.

k. Provide appropriate information to justify the SEM design approach taken.

l. Provide information as to the extent of SEM module subcontracting anticipated.

It is recognized that such information disclosure from a bidder may not be possible unless a contract definition phase precedes contract award. In such a case many of the above items can be established.

7.2.2.6 Criteria for evaluation. The RFP/RFQ should clearly establish by what criteria the contractor's proposal will be evaluated. The contractor should not be misled into thinking that he must either use the most SEM standards or least total modules, fewest new SEM, etc., for it is not intended to promote the use of SEM for the SEMP's sake. What is important is that the implementation be optimized within the constraints of the particular program in order that proposals will be cost effective over the equipment's life cycle.

There is probably no single "best" way to utilize SEMP modules and design requirements. It is important, however, that the intended principles of the SEMP be maintained. These principles are as follows.

a. Maximize use of existing SEM.

b. Design new SEM only where it is cost effective to do so.

c. Design new SEM in a manner that will facilitate their becoming standards.

c. Minimize SEM types.

e. Design new SEM such that they can be discarded upon failure.

f. Design new SEM such that they are not dependent upon a single technology or use of special or proprietary components.

The program manager, when preparing the RFP/RFQ, should require that the use of SEMP modules and design requirements be optimized for the system requirements. Contractors should be required to conduct trade-off studies to support such optimization decisions and include these analyses in their technical proposals.

7.2.2.7 Clarification of responsibilities. When preparing the RFP/RFQ, the program manager should also clearly define the specific responsibilities of the contractor for implementing SEMP documentation and qualification requirements for new module designs. This can be a potential problem area because the classification of new SEM does not usually occur until after a contract has been awarded. The problem is that the proposing contractors do not know whether their new module designs are to be SEM standards at the time of proposal submission and whether to propose for cost purposes that they be functionally specified and qualified. This problem can be divided into two distinct parts and can be treated accordingly.

a. First, who shall be responsible for qualification testing costs at the SEMP-QAA. This question often concerns system contractors proposing SEM requirements and the program manager should resolve this issue early in the RFP/RFQ stage. To date, all system applications of SEM have resulted in the program manager establishing funding at the SEMP-QAA for qualification rather than having system contractors responsible for this effort. This has proven desirable, not only from the standpoint of obviating a basically unorthodox funding relationship (industry to government), but eliminates an added overhead burden. The program manager, therefore, should state within the RFP/RFQ that.

   "Qualification funding. All costs incurred by the SEMP-QAA in qualifying SEM will be funded by the acquiring activity."

b. The second part of the problem concerns the contractors' responsibility for their costs associated with new SEM standards. Again, at the time of proposal submittal new module designs are not as yet classified or even determined. Therefore, how should the contractor treat the following contingencies?

   (1) Costs for fabricating module samples for submission to the SEMP-QAA for qualification and correlation.

   (2) Costs for functionally specifying new SEM standards.

   (3) Costs for accomplishing tester correlation and acceptance testing.

c. Some possible alternatives which might be considered are:

   (1) Not require that the cost for providing SEMP functional specifications and qualification for proposed new SEM be factored into the costing of the proposal. However, contractors should be directed to propose an average unit cost for such services in the event an option is exercised for such services at a future date. This would allow time to determine classification of any new module designs while providing the necessary costing information for evaluation prior to contract award. Such an option, if delayed until after contract award, would obviously require additional funding requirement and contract modification unless a cost-plus type contract were employed.

(2) To require that responding contractors coordinate their proposed new module requirements with the Design Review Activity prior to proposal submission and cost out their hardware mechanization based upon tentative classifications rendered by the Design Review Activity.

(3) To require that all new SEM be functionally specified and qualified regardless of classification (i.e., standard or special). This can be of value if system requirements call for high-reliability components, or if few new module designs are anticipated.

(4) In the event of an engineering model, prototype, or preproduction equipment acquisition, choose not to require SEMP functional specifications and qualification at that time. Such requirements could be tentatively delayed until some future time or be required prior to, or as part of, a subsequent production phase.

The program manager may wish to establish other criteria for resolving the difficulty in determining such costing depending upon particular requirements. The important item is that this factor be recognized and addressed in a manner which will entail a minimum of contractual complications and subsequent cost impact.

7.2.2.8 Specification of non-hardware SEMP items. When specifying non-hardware SEMP requirements within the RFP/RFQ, such specification must be accomplished by use of DD Form 1423, Contract Data Requirements List, and DD Form 1664, Data Item Description. Data Item Descriptions applicable to the SEMP are as follows:

a. Nonstandard Part Approval Requests/Proposed Additions to an Approved PPSL, DI-E-7028.

b. Report, Failure Analysis for the Standard Electronic Modules Program (SEMP), DI-E-7045.

c. Request, Design Approval for the Standard Electronic Modules Program (SEMP), DI-E-7042.

d. Request, Exception, Standard Electronic Modules Program (SEMP), DI-E-7044.

e. Specifications, Standard Electronic Modules Program (SEMP), DI-E-7043.

7.2.3 SEM specification within contracts. The actual specification of SEM requirements within the contract work statement will essentially be identical to that used for the RFP/RFQ (see 7.2.2). The significant aspects of the contractor's proposal should also be incorporated into the contract. Such factors might include the following:

a. Allowable deviations from SEM implementation.

b. Schedule for design approval request submittal, specification preparation, and module qualification submission.

c. Costing estimates for specification preparation or module qualification (if required in the future by the program manager).

7.3 Evaluating SEM configured system proposals. The SEMP does not endorse a specific procedure or rationale for the evaluation of proposals. It does this because it is recognized that the circumstances of each program are largely unique and to attempt to utilize a hard-and-fast rule for rating proposals would be too constraining for the evaluator. This section does present various aspects of proposal review and, hopefully, will bring to light various factors relating to SEM which should be considered by the program manager to establish the review method that will best meet his specific requirements.

7.3.1 Evaluation objective. The objective should be one of determining whether stated system performance requirements are met, as well as identifying which will result in the lowest operational life cycle cost. The means to meet this end are subject to many variables and, therefore, difficult to comprehensively define. The basic guidelines of the SEMP, as noted below, are considered to be key determinants in achieving a lower life cycle cost

a. Maximized use of existing SEM.

b. Maximize the identification and incorporation of design characteristics which promote discard at failure for all SEM as the most cost effective maintenance and logistics support plan.

c. Develop new modules in a manner such that they can be candidates for inclusion into the SEMP standards.

d. Evaluation and determination of the impact on avionics equipment design and total life cycle cost of designating a SEM as either a line replaceable unit (LRU) or a component of a LRU.

Although the above guidelines are general in nature, their use is subject to the specific application of the program. Such guidelines have been generally accepted as major factors in life cycle costing and, for the lack of other guidance to meet life cycle cost goals, they should be strongly considered.

7.3.2 Establishment of a review team. It has been proven extremely effective for a program manager to form a special group or team to review and evaluate the SEM portions of contractor proposals. In many cases this team has been singly tasked with the responsibility for dealing with the overall standardization aspects (of which SEM are but one portion) of the proposals.

Many program managers have utilized the services of representatives from the Design Review Activity and Quality Assurance Activity for participation as proposal review team members. They, along with representatives from the program management office and other support activities as deemed necessary by the program manager, review and evaluate SEM aspects of all contractor proposals. This combined approach has proven extremely effective because of the concentration of individuals with specific experience at each of these facilities. Arrangements for such support services can generally be made without incurring involved contracting procedures and could be added to the normal scope of services that the program manager may already require from these facilities. Section 6 of this handbook contains additional details relative to establishing SEMP funding relationships.

7.3.3 Method for evaluating SEMP factors in system proposals. The program manager must determine which proposal is the best from both the aspect of his particular requirements and from the standpoint of SEM optimization. It is assumed for the purpose of this document that these two objectives are synonymous. To accomplish such an evaluation in a timely manner, an evaluation method or procedure should be established prior to the receipt of proposals.

7.3.3.1 Determination of key items. The following is a list of commonly employed key items which have been used as the basis for reviewing and evaluating previous SEM proposals. The program manager should determine which of these key items will be appropriate for his particular system evaluation:

a. Has the contractor proposed to deviate from SEM requirements? If so, was such a deviation adequately justified?

b. What is the total number of SEM required to implement system hardware requirements?

c. What is the total number of existing SEM to be used?

d. What is the number of existing SEM types to be used?

e. What percentage of the system is comprised of existing SEM?

f. What percentage of the system is comprised of SEM special modules?

g. What is the total system population of new SEM types?

h. What is the number of new SEM types used?

i. What percentage of the system is comprised of new SEM?

j. What is the number (and percentage) of new SEM which are potential SEMP standards?

k. When applying item (j) above to existing SEMP standards, what is the new distribution of SEMP standards within the system?

l. Has the contractor attempted to increase the functionality (complexity) of SEM specials to minimize types?

m. What number and percentage of proposed SEM are candidates for a discard upon failure maintenance concept?

n. Has the use of advanced technologies been applied to minimize the number of SEM types?

o. Has the use of appropriate electronic technology been maximized?

p. In the event of retrofitting an existing SEM system, what is the degree of SEM commonality between the existing system and the proposed modification?

q. How will the selected SEM impact the total equipment MTBF?

r. What are the size requirements for new SEM?

s. Which design approach results in the smallest physical size?

t. Which design approach results in the smallest thermal load?

u. Does the order of priority of SEM used conform with the requirements of MIL-STD-1378?

v. Which SEM implementation approach will result in the lowest life cycle cost?

w. Which SEM implementation approach maximizes module commonality with other SEM systems on the same platform?

x. Which SEM architecture approach (partitioning methods) would present the least amount of potential cost risk?

y. Does the contractor demonstrate an understanding of the principles and requirements of the SEMP?

7.3.3.2 Determination of key item weights. Upon establishing the applicability of selected key items, the program manager will find that all key items may not be of equal importance. To resolve this point, the assignment of weights should be considered. Weighting is also dependent upon the particular application and must be approached on a system by system basis. Key items have usually been weighted on a relative scale from 0 to 1.0 with one-tenth (0.1) increments.

7.3.3.3 Rating process. Upon determination of appropriate key items and a weighting system, the proposals can now be related to one another. This can be accomplished by scoring each contractor's performance for a certain key item category from 0-100. Normally 10 point rating increments have been used but finer gradations can be employed if so desired.

Figure 3 illustrates a typical evaluation sheet which has been employed on a previous SEM system application. Each key item raw score is factored by a particular weight and then totaled. This total then is divided by the summation of weights to arrive at the overall implementation element score. This process should be followed for each contractor's proposal in order that the most effective one can be identified.

7.3.3.4 Impact of scoring process. Obviously there are factors to be considered in the evaluation process other than the SEM aspects. Therefore, the program manager will probably weigh the score of the SEM implementation element relative to its importance to the entire program.

EVALUATION SHEET

ELEMENT SCORE

Element SEM implementation

Panel ______

Group ______

Unit ______

$\frac{S}{n}$

Key items	Relative weight (0-1 0)	Raw item score (0-100)	Weighted item score (0-100)
1			
2			
3			
4			
5			
.			
n			
	Summation of weights = n		Summation of weighted scores = S

Evaluator's comments:

FIGURE 3 Evaluation sheet format.

8. CONSIDERATIONS UPON CONTRACT AWARD

8.1 Introduction. Upon contract award, the program manager should recognize and act upon a number of considerations which will impact upon his particular program as a result of SEM implementation. This section identifies such items and discusses them relative to their impact on program requirements.

8.2 Specification change control. Changes to an existing SEM standard are initiated by the completion and submission of a Standardization Document Improvement Proposal (Form 1426) to the SEMP Management Activity, Naval Electronic Systems Command, Code 8134. Program managers, therefore, should ensure that all such proposals initiated either by themselves, their systems contractor, or a joint government/contractor configuration management activity are absolutely necessary to their particular program application.

Revisions to SEM detail specifications and other requirements documents are usually limited to areas which do not impact module interchangeability for all users concerned. In the event that a proposed revision is rejected, either because of adversely affecting the interchangeability of a common module, or altering the desirability of that module remaining a SEMP standard, the program manager can accept a new module key code for the module if the revision must be incorporated. This would likely result in the module being reclassified as a special module.

It should be noted that this alternative presents considerable disadvantages some of which are noted as follows:

a. The module would likely be reclassified as a special module.

b Module costs would likely increase because of the resultant limited production requirement.

c. Redocumentation could be costly and time consuming.

d. Added qualification and logistics costs would result.

8.3 Waivers and deviations. In the event that a SEM is deployed within a prototype or preproduction equipment prior to completion of the qualification approval cycle, or where changes must be made to SEM standards already deployed (for rework), the program manager should be prepared to exercise several prerogatives in case the module subsequently fails its initial qualification. The program manager should take action to ensure that modules of that type already deployed will not be used by others in subsequent system applications even though such modules lack the "JAN" marking signifying successful qualification and full compliance with all requirements of the module specification. It is strongly recommeded that the program manager take appropriate action to identify those modules already deployed as not being qualified and representative of the approved version. Such action should be taken regardless of whether the causes of module failure affect its performance in its initial system application.

8.4 Establishment of a failure reporting system. The use of SEM does not guarantee that all modules will have standard or constant failure rates. The specific system application will be the final determinant of module reliability. It would be wise for the program manager to consider establishing a procedure for reporting, analyzing, and compiling module failure data within the particular system application.

Although there is no specific SEMP requirement or procedure for accomplishing SEM failure reporting and analysis several program managers have utilized the facilities of the SEMP-QAA for such activities. This has proved extremely effective because of the quality assurance responsbilities already assigned to the SEMP-QAA. The SEMP QAA

is prepared to assume similar support roles for all SEM system program managers and can assist in the establishment of a total failure reporting and analysis system

8.5 Design review meetings. The program manager should conduct periodic design review meetings to monitor and ensure that the systems contractor is fulfilling his obligations relative to implementing SEM requirements. From past experience such meetings have been extremely helpful in identifying potential problem areas that might arise in the SEM implementation program as well as providing a continuing forum in the event the SEMP plan was not fully defined at the time of contract award. Specifically, such meetings aid in controlling the following:

a. Establishing and monitoring schedules for contractor milestones; such as, DAR submission, specification preparation, correlation, and qualification sample submission.

b. Establishing and monitoring schedules for SEMP-QAA milestones; such as, specification review, performance of correlation, and test initiation and completion.

c. Resolving technical difficulties experienced with specific module designs.

d. Establishing alternate test plans for special modules.

It is strongly urged that the program manager plan to retain the services of the appropriate SEMP activity to assist in such meetings.

9. NOTES

9.1 Program manager check list. See appendix A for a suggested program manager check list.

Custodians:
Army - ER
Navy - EC
Air Force - 85

Review activities:
Army - AR, AT, AV
Navy - AS, SH
Air Force - 11, 13, 17, 19
DLA - ES

User activities:
Army - MI
Navy - MC
Air Force -

Agent:
DLA - ES

Preparing activity:
Navy - EC

(Project 5963-0019)

APPENDIX A

PROGRAM MANAGER CHECK LIST

EVENT	REF. PARAGRAPH
PRE CONTRACT	
Reference SEM intentions within TDP	7.2.1
Arrange for SEMP orientation	6.3
Conduct technical and LCC analysis	5.2
Determine scope of SEM applicability	7.2.2.2
Establish program office SEM coordinator	8.1
Define SEM requirements within RFP/RFQ	7.2.2.5 & 7.2.2.7
Define SEM evaluation criteria and incentives	7.2.2.6
Establish SEM evaluation team	6.3.1 & 7.3.2
Evaluate SEM proposals	7.3
CONTRACT AWARD	
Establish contractor SEM milestones	8.5
Coordinate with SEMP-QAA for quality assurance requirements	6.2, 6.2.1, 6.4, & 6.5
Coordinate with SEMP-QAA for utilization of module pool	6.2.1
Coordinate with SEMP-QAA for test plan for SEMP specials	6.2.1
Establish failure reporting system	8.4
Conduct SEM design reviews	8.5
Monitor program	8.3

APPENDIX B

LIFE CYCLE COSTING EXAMPLE

10. Life cycle costing example. The costing example that follows is based upon a hypothetical system implemented with SEM versus the same system implemented with non-SEM. To perform this analysis the following assumptions are made.

a. The functional parts of the system have been defined and the Government plans to acquire 100 systems. The system life is 10 years.

b. A preliminary design has been completed and the following determined

(1) The SEM system will require 30 module types to implement the design, 18 are existing SEM standards, two are new SEM standards, and 10 are special modules.

(2) A total of 1,000 modules will be required to implement the system.

(3) All SEMP module types are presumed to be of equal complexity and equivalent to the standard MIL-M-28787/6 module.

c. Fifty percent of the total SEMP module count is composed of standards, therefore, on an average, there will be 25 standard modules/type/system and 50 special modules/type/system.

d. Based on 5.2.3d, the number of non-SEMP modules per system is $\frac{1,000}{3}$ and the total number of module types is 30 x 1.5 = 45.

e. The reliability of each SEM type is assumed to be 0.095 failures per million hours, the failure rate of a MIL-M-28787/6 module. The failure rate of the non-SEM is 5 x 0.095 = 0.475 failures per million hours.

f. From table I the cost of a SEM is $32.00 and the cost of a non-SEM will be $32.00 x 3 = $96.00.

g. An initial sparing philosophy requires two spares per module type per system.

h. All non-SEM are repairable, therefore, in the non-SEM $K_{Ri} = 1$. Only SEM special modules are repairable. The repair cost of a repairable module is assumed to be 50 percent of its initial cost.

i. Pipeline assets will be assumed to be zero. This assumption is reasonable for two reasons. First, if the time t_{DS}, t_{SR}, and t_{RD} are assumed to be < 100 hours, the PA cost becomes negligible compared to other costs. Second, t_{DS}, t_{SR}, and t_{RD} will vary significantly from program to program and it should be left to the program manager to judge its contribution to the total program cost.

j. Terminal value 3/ = $TV = \sum_{i=1}^{N_T \text{ (SEM standards)}} N_i C_{mi} K_{TVi}$

where K_{TV} is assumed to be 0.25.

3/ Terminal value should be considered only if a total population of at least 20 modules of a particular type exists among 2 or more systems. It should be noted that the terminal value used in the example is only the value of the SEM that remain in each system at the end of system life. This was done because, other than those modules, the only other source of modules associated with each system is the spares remaining in the pipeline. Since the pipeline costs were not included for the reasons stated previously, including them as assets would present a somewhat distorted cost picture.

10.1 SEM costing equation. For the SEM system the costing equation is:

$$\text{Total SEM program LCC} = \sum_{i=1}^{N_T(\text{New standards})} i(SMDC + SMQC) + \sum_{i=1}^{N_T(\text{Specials})} i(SPMDC + SPMQC) + \begin{pmatrix}\text{Number of}\\ \text{systems to}\\ \text{be acquired}\end{pmatrix}$$

$$\left[\sum_{i=1}^{N_T(\text{Standards})} N_i\, C_{mi} \left\{\left(1 + \frac{N_{si}}{N_i}\right) + t_L\, \lambda_{mi}\right\} + \sum_{i=1}^{N_T(\text{Specials})} N_i\, C_{mi} \left\{\left(1 + \frac{N_{si}}{N_i}\right) + t_L\, \lambda_{mi}\,(1 + K_{Ri}\, K_{CORi} - K_{Ri})\right\} - TV\right]$$

where

SMDC = \$33.7K (This cost is already expended for existing standards.)

SMQC 4/ = \$2.7K

SPMDC = \$28.0K

For an explanation of MDC and MQC see 5.3.

Number of systems to be acquired = 100

N_T (Standards) = 20, N_i = 25

N_T (Specials) = 10, N_i = 50

$\lambda_{m1} = \lambda_{m2} = \ldots = \lambda_m = 0.095$ failures per million hours

$C_{m1} = C_{m2} = \ldots = C_m = \$32$ (see table I)

$K_{Ri} = 1$

$Ri = 1$

$K_{CORi} = 0.50$

t_L = 10 years = 87,600 hours

$$\sum_{i=1}^{N_T(\text{New standards})} i = 2$$

$$\sum_{i=1}^{N_T(\text{Specials})} i = 10$$

$$\sum_{i=1}^{N_T(\text{Standards})} N_i = 500$$

$$\sum_{i=1}^{N_T(\text{Specials})} N_i = 500$$

$$\sum_{i=1}^{N_T(\text{Total})} \frac{N_{si}}{N_i} = \frac{2 \times 30}{1,000}$$

4/ This is a cost incurred for periodic qualification testing.

Therefore,

$$\text{Total SEM program LCC} = 2(SMDC + SMQC) + 10(SPMDC + SPMQC) + \binom{\text{No. of systems}}{\text{to be acquired}}\left[(500)\ C_m\left\{\left(1 + \frac{60}{1,000}\right) + \lambda_m t_L\right\} + 500\ C_m\left\{\left(1 + \frac{60}{1,000}\right) + \lambda_m t_L\left[1 + k_{CORi} - 1\right]\right\} - TV\right]$$

$$= 72.8K + 280.0K + (100)\left[(500)(\$32)\left\{(1 + 0.06) + (0.095 \times 10^{-6})(8.76 \times 10^4)\right\} + (500)(\$32)\left(1\left(+ 0.06\right) + (0.50)(0.095 \times 10^{-6})(8.76 \times 10^4)\right) - TV\right]$$

$$\text{Total SEM program LCC} = \$72.8K + \$280.0K + 100\left[\$16K\ (1.0683) + \$16K\ (1.0641) - TV\right]$$

$$= \$72.8K + \$280.0K + \$3411.84K - (500\ \text{mod/sys} \times 100\ \text{sys} \times \$32 \times 0.25)$$

$$= \$3,764,640 - \$400,000 = \$3,364,640$$

Total SEM program LCC = $3,364,640

10.2 <u>Non-SEM costing equation</u>. For the non-SEM system the costing equation is.

$$\text{Total non-SEM program LCC} = \sum_{i=1}^{N_T(\text{non-SEM})} i(MDC) + \binom{\text{No. of systems}}{\text{to be acquired}} \left[\sum_{i=1}^{N_T} N_i\ C_{mi}\left\{\left(\left(1 + \frac{N_{si}}{N_i}\right) + \lambda_{mi}\ t_L\left[1 + K_{Ri}\ (K_{CORi} - 1)\right]\right)\right\} - TV\right]$$

where:

TV 5/ = 0
MDC = $30.5K
No. of systems to be acquired = 100

$$\sum_{i=1}^{N_T(\text{non-SEM})} i = (30\ \text{SEM types})\ (1.5\ \text{non-SEM types/SEM types}) = 45$$

$$\sum_{i=1}^{N_T} N_i = (1,000\ \text{total SEM types})\ (1/3\ \text{non-SEM types/SEM types}) = \frac{1000}{3}$$

$C_{mi} = C_{m1} = C_{m2} = \ldots = C_{m45}$ = $32 SEM cost x 3 = $96

$\lambda_{mi} = \lambda_{m1} = \lambda_{m2} = \ldots = \lambda_{m45}$ = (0.095 failures/million hrs SEM failure) x (5)
= 0.475 failures/ million hrs
= 0.475×10^{-6} failures/hr

N_{si} = Initial sparing is 2 spares per module type = 2 x 45 = 90

K_{Ri} = 1, R_i = 1 (all the modules are repairable)

K_{CORi} = 0.50

5/ Only SEM have terminal value, because they can be used in other systems (see 5.2.3.j).

$$\text{Total non-SEM program LCC} = (45)(\$30.5K) + 100\left[\left(\frac{1{,}000}{3}\right)(\$96)\left\{\left(1 + \frac{90}{\frac{1{,}000}{3}}\right)\right.\right.$$

$$\left.\left. + \left[0.5\right](0.475 \times 10^{-6})(8.76 \times 10^{4})\right\}\right]$$

$$= \$1{,}372.5K + 100\left[32.0K\left(1.290805\right)\right]$$

$$= \$1.372.5K + \$4{,}130.6K$$

$$\text{Total non-SEM program LCC} = \$5{,}503{,}100$$

10.3 Example results. As can be seen from the completed costing example, the SEM versus non-SEM total program life cycle cost was $3,364,640 versus $5,503,100, respectively, resulting in a net savings of approximately 39 percent through the use of the SEM. It must be recognized that although these figures were derived from a "hypothetical" system analysis comparison was based upon actual SEM and non-SEM data and relationships with the results likely to be representative for other system applications of this size and quantity.

10.4 Costing summary. The program manager/engineer may find it more useful to present the various program costs in a tabulated form instead of simply calculating the total utilizing the composite equation (9). Tabulation of the costs can be readily accomplished by calculating and tabulating the individual cost associated with equation (1), that is, the tabulation of module development and qualification costs and the various costs associated with equations (3) through (8). The sum of these tabulated costs constitute the total program life cycle cost.

Table III shows a tabulation of the various costs associated with the example system presented in this costing section

TABLE III. Total program life cycle cost comparison format.

Cost item	SEM	Non-SEM
Module development cost (MDC)	$ 347.4K	$ 1,372.5K
Module qualification cost (MQC)	5.4K	---
Initial cost of modules (CSM)	3,200.0K	3,200.0K
Initial module spares cost (CIS)	192.0K	864.0K
Replenishment spares cost (CRS)	13.2K	---
Cost of module repair (CMR)	6.6K	66.6K
Pipeline assets (PA)	---	---
Terminal value (TV)	-400.0K	---
Total program life cycle cost	$ 3,364.6K	$ 5,503.1K

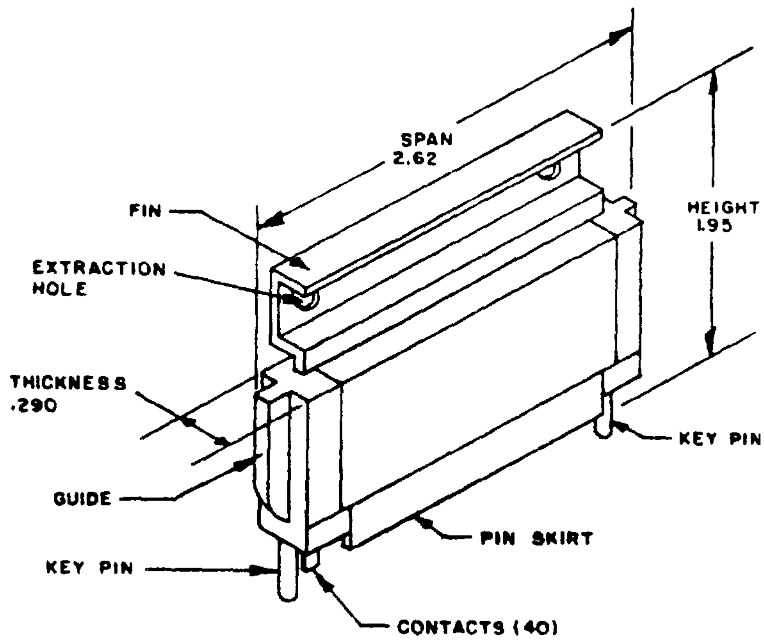
APPENDIX C

STANDARD ELECTRONIC MODULES DESCRIPTION

10. SCOPE

10.1 Scope. This appendix describes standard electronic modules.

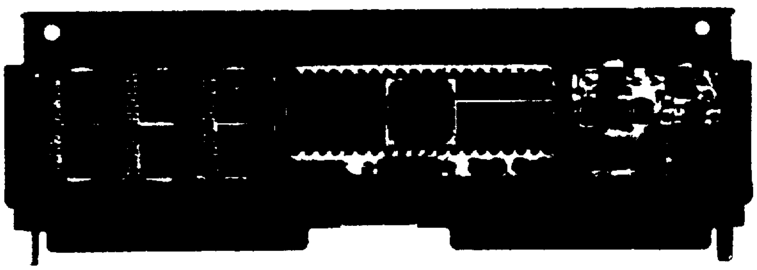
10.2 FORMAT A configuration. The basic SEM configuration is the single span, single thickness FORMAT A (size 1A) configuration, with overall dimensions of 2.62 inches (66.55 mm) in width, 1.95 inches (49.53 mm) in height, and 0.290 of an inch (7.37 mm) in thickness. There are also provisions for multiple growth increments permitting modules to increase in span by increments of 3.00 inches (76.20 mm) and in thickness by increments of 0.300 of an inch (7.62 mm).



INCHES	MM
0 290	7 37
1 95	49 53
2 62	66 55

10.3 FORMAT B configuration. As technology advances warranted increased functional densities, the SEMP developed the FORMAT B expanded capability module configuration which provides increased circuit area, thermal interface area, and number of connector pins.

10.4 Examples. The following depicts examples of FORMAT A (size 2A) and FORMAT B module configurations



FORMAT A CONFIGURATION

FORMAT B CONFIGURATION

20. MECHANICAL

20.1 Mechanical components The component parts of a typical size 1A SEM are described as follows.

2[illegible] [illegible] structure A f[illegible] structure serves as the identification marking surface, [illegible]ract[illegible] interface, and means for heat dissipation Two holes in the fin aid in [illegible] removal by use of an extraction tool

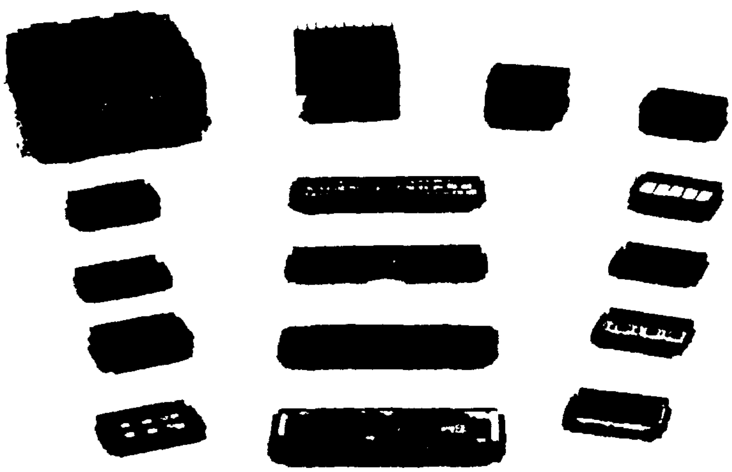
20.3 Guides. The guides at each end of the module span aid in its alignment in the card cage and in the mating of the module contacts with the mounting structure connector. They also provide a means for dissipating heat.

20.4 Contact pins. The portion of each male contact protruding from the module connector header surface is controlled to insure proper engagement of the module and its interface mounting structure For all FORMAT A and FORMAT B (size 1A) configurations, contacts are arranged in two rows of 20 contacts each on a 0.100 inch (2.54 mm) grid system to form connector increments. Each increment may have a maximum of 40 contacts or a minimum of 20 contacts per module. FORMAT B (size 2A) modules have two rows of 50 contacts for a total of 100 contacts per module.

20.5 Key pins. Two keying pins insure the proper mating of the module to its appropriate interface connector. Each module type is assigned a three letter key code which establishes the configuration and rotational position of two uniquely configured keying pins

20.6 Pin shields. Two pin shields act as protective covers for the module contacts and provide a contact marking surface.

20.7 Examples. The flexibility of the SEMP mechanical form factor for accommodating a variety of module sizes and construction technologies is demonstrated by the following photograph.



30. ELECTRICAL

30.1 Electrical requirements. In order that the basis for standardization could be effected, the SEMP established the following electrical requirements.

30.2 Functional partitioning. Each standard module shall be a complete function or group of functions specifiable and testable without dependence upon another module. Multiple function capability, however, may be incorporated within a particular module by means of either pin programming or voltage control.

30.3 Standard digital interface parameters. Digital modules are to employ standardized digital logic levels and power supply voltages

30.4 Module contact pin assignment. Module power supply, circuit ground, frame ground, and signal l' es have been assigned to specific contact pins on the module connector. These requirements have been established to facilitate the use of commonly available automated power and ground bussing and interconnecting techniques.

30.5 Component selection. Electronic components used in modules shall have a demonstrated quality level and environmental performance equivalent to that of available military parts

30.6 Semiconductors. Discrete semiconductors shall meet the TX requirements of MIL-S-19500 and the applicable detail specification. Integrated circuits shall meet the requirements of MIL-M-38510, class B, and the applicable detail specification.

INSTRUCTIONS: In a continuing effort to make our standardization documents better, the DoD provides this form for use in submitting comments and suggestions for improvements. All users of military standardization documents are invited to provide suggestions. This form may be detached, folded along the lines indicated, taped along the loose edge (*DO NOT STAPLE*), and mailed. In block 5, be as specific as possible about particular problem areas such as wording which required interpretation, was too rigid, restrictive, loose, ambiguous, or was incompatible, and give proposed wording changes which would alleviate the problems. Enter in block 6 any remarks not related to a specific paragraph of the document. If block 7 is filled out, an acknowledgement will be mailed to you within 30 days to let you know that your comments were received and are being considered.

NOTE: This form may not be used to request copies of documents, nor to request waivers, deviations, or clarification of specification requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(*s*) or to amend contractual requirements.

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STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions – Reverse Side)

1. DOCUMENT NUMBER	2. DOCUMENT TITLE

3a. NAME OF SUBMITTING ORGANIZATION	4. TYPE OF ORGANIZATION *(Mark one)*
b. ADDRESS *(Street, City, State, ZIP Code)*	☐ VENDOR ☐ USER ☐ MANUFACTURER ☐ OTHER *(Specify)* ______

5. PROBLEM AREAS

a. Paragraph Number and Wording

b. Recommended Wording

c. Reason/Rationale for Recommendation

6. REMARKS

7a. NAME OF SUBMITTER *(Last, First, MI)* – Optional	b. WORK TELEPHONE NUMBER *(Include Area Code)* – Optional
c. MAILING ADDRESS *(Street, City, State, ZIP Code)* – Optional	8. DATE OF SUBMISSION *(YYMMDD)*