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DEPARTMENT OF DEFENSE STANDARD PRACTICE

RELIABILITY-CENTERED MAINTENANCE (RCM) PROCESS

AMSC 9473 AREA PSSS

FOREWORD

1. This standard is approved for use by all Departments and Agencies of the Department of Defense.

2. For the purpose of this standard, the term "ship" refers to submarines, surface ships, aircraft carriers, and craft.

3. Comments, suggestions, or questions on this document should be addressed to: Commander, Naval Sea Systems Command, ATTN: SEA 05S, 1333 Isaac Hull Avenue, SE, Stop 5160, Washington Navy Yard DC 20376-5160 or emailed to CommandStandards@navy mil, with the subject line "Document Comment". Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at https://assist.dla.mil.

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1. SCOPE

1.1 Scope. This standard describes the Reliability-Centered Maintenance (RCM) (see 3.16.9) methodology used for the determination of maintenance requirements. It applies to all levels of system or equipment grouping, and to all scheduled maintenance, whether equipment is in use, ready for use, or in standby or lay-up condition. RCM addresses the total scheduled maintenance program for an enterprise; that is, organizational, intermediate, and depot level maintenance, regardless of the maintenance echelon possessing the capability to perform the maintenance. RCM methodology provides the foundation for a Condition Based Maintenance (CBM) program. The relationship between RCM and CBM+ technologies is included in Appendix F. This standard provides the procedure to develop corrective, inactive, and preventive equipment maintenance within a planned maintenance management system. Specific maintenance procedures may be developed, after the application of the RCM procedure outlined in this standard, for inclusion in class maintenance plans, and depot, intermediate, and organizational maintenance systems. Maintenance (corrective, inactive, and preventive) (see 3.15.3, 3.16.5, and 3.16.8, respectively) is the action of performing tasks (condition-directed, failure-finding, lubrication, servicing, and time-directed) (see 3.28.2, 3.28.4, 3.28.5, 3.28.6, and 3.28.7, respectively) at periodicities (periodic, situational, and unscheduled) to ensure the item's functions (active, evident, hidden, and passive) (see 3.13.1, 3.13.2, 3.13.3, and 3.13.4) are available when required. For the purpose of this standard, the term "ship" refers to submarines, surface ships, aircraft carriers, and craft.

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3, 4, or 5 of this standard. This section does not include documents cited in other sections of this standard or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3, 4, or 5 of this standard, whether or not they are listed.

2.2 Government documents.

2.2.1 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

DOD INSTRUCTIONS

DODI 4151.22	-	Condition Based Maintenance Plus (CBM+) for Materiel Maintenance
DOD 4151.22M	-	Reliability Centered Maintenance (RCM)

(Copies of these documents are available online at www.dtic.mil/whs/directives/.)

FLEET FORCES COMMAND

COMFLTFORCOMINST 4790.3, Volume V	-	Joint Fleet Maintenance Manual

(Copies of this document are available online at http://submepp.ahf nmci.navy.mil/.)

NAVAL SEA SYSTEMS COMMAND (NAVSEA) PUBLICATIONS

SS800-AG-MAN-010/P-9290	-	System Certification Procedures and Criteria Manual for Deep Submergence Systems

(Copies of this document are available online at https://nll.ahf nmci navy mil, may be requested by phone at 215-697-2626, or may be requested by email at nllhelpdesk@navy mil. This publication can be located by searching the Navy Publications Index for the TMIN without the suffix.)

NAVAL SUPPLY SYSTEMS COMMAND (NAVSUP) PUBLICATIONS

The Afloat Shopping Guide (ASG)

(Copies of this document are available via subscription to Federal Logistics Data on Portable Media (FED LOG). To subscribe to FED LOG, visit http://www.dlis.dla mil/Fedlog/subscription/.)

NAVSEA INSTRUCTIONS

NAVSEAINST 4790.1	-	Expanded Ship Work Breakdown Structure (ESWBS) Hierarchical Structure Codes (HSC) for Ships, Ship Systems and Surface Combatant Systems
NAVSEAINST 4790.8	-	Ships' Maintenance and Material Management (3-M) Manual
NAVSEAINST 4790.27	-	Reliability-Centered Maintenance (RCM) and Condition-Based Maintenance (CBM) Policy for Ships, Ship Systems, and Equipment

(Copies of these documents are available online at http://www navsea navy mil.)

OPNAV INSTRUCTIONS

OPNAVINST 4700.7	-	Maintenance Policy for United States Navy Ships
OPNAVINST 5513.1 (series)	-	Department of the Navy Security Classification Guides

(Copies of these documents are available online at http://doni.documentservices.dla mil/default.aspx.)

SUBMEPP

0924-062-0010	-	SUBSAFE Requirements Manual

(Copies of this document are available online at http://submepp.ahf nmci.navy.mil/.)

2.3 Order of precedence. Unless otherwise noted herein or in the contract, in the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. DEFINITIONS

3.1 Acronyms used in this standard. The acronyms used in this standard are defined as follows:

3-M	Maintenance and Material Management
ACR	Allowance Change Request
AE	Age Exploration
AEL	Allowance Equipage List
AFSI	Additional Functionally Significant Item
AMSC	Acquisition Management Systems Control
AN	Army – Navy
ANSI	American National Standards Institute
APL	Allowance Parts List
ASG	Afloat Shopping Guide
ASME	(Formerly) American Society of Mechanical Engineers
ASTM	(Formerly) American Society for Testing and Materials

BITE	Built-In Test Equipment
CAGE	Commercial and Government Entity
CBM	Condition-Based Maintenance
CD	Condition-Directed
CDRL	Contract Data Requirements List
CM	Change Material
CMP	Class Maintenance Plan
CMRS	Calibration and Measurement Requirement Summary
CNO	Chief of Naval Operations
COTS	Commercial-Off-the-Shelf
CP	Change Procedure
CPLT	Corrosion Prevention Logic Tree
DCA	Damage Control Assistant
DoD	Department of Defense
DoN	Department of the Navy
EM1	Electrician's Mate First Class
EMO	Electronic Material Officer
EPA	Environmental Protection Agency
ESWBS	Expanded Ship Work Breakdown Structure
ET2	Electronics Technician Second Class
FBD	Functional Block Diagram
FC1	Fire Control Technician First Class
FF	Failure Finding
FFA	Functional Failure Analysis
FGC	Functional Group Code
FMA	Fleet Maintenance Activity
FMEA	Failure, Modes, and Effects Analysis
FSI	Functionally Significant Item
GM2	Gunner's Mate Second Class
GMM2	Gunner's Mate Missiles Second Class
GPETE	General Purpose Electrical/Electronic Test Equipment
HAP	Hazardous Air Pollutants
HDBK	Handbook
HSC	Hierarchical Structure Code

IEM	Inactive Equipment Maintenance
IMA	Intermediate Maintenance Activity
ISEA	In-Service Engineering Agent
LORA	Level of Repair Analysis
LTA	Logic Tree Analysis
LU	Lay-Up
LU(I)	Lay-Up (Industrial)
MCA	Maintenance Coordinating Activity
MDA	Maintenance Development Activity
MDS	Maintenance Data System
MIL	Military
MIP	Maintenance Index Page
MK	Mark
MM2	Machinist's Mate Second Class
MOD	Model
MR	Maintenance Requirement
MRC	Maintenance Requirement Card
MRI	Maintenance Requirements Index
MSSI	Master System and Subsystem Index
MTBF	Mean Time Between Failures
MTTR	Mean Time To Repair
NAVSEA	Naval Sea Systems Command
NAVSEACEN	Naval Sea Support Center
NAVSUP	Naval Supply Systems Command
NC	No Change
NEC	Navy Enlisted Classification
NSLC	Naval Sea Logistics Center
NSN	National Stock Number
NSTM	Naval Ships' Technical Manual
OEM	Original Equipment Manufacturer
OM	Omit
OP	Ordnance Publication
OPNAV	Office of the Chief of Naval Operations
OSHA	Occupational Safety and Health Administration
OS1	Operations Specialist First Class
OT	Operational Test

PM	Periodic Maintenance
PM (M)	Periodic Maintenance (Monthly)
PM (W)	Periodic Maintenance (Weekly)
PMS	Planned Maintenance System
PPE	Personal Protective Equipment
PRF	Performance
RADIAC	Radiation Detection, Indication, and Computation
RCM	Reliability-Centered Maintenance
RMC	Regional Maintenance Center
SCAT	Sub-Category
SECNAV	Secretary of the Navy
SLA	Servicing and Lubrication Analysis
SOH	Safety and Occupational Health
SOT	System Operability Test
SPETE	Special Purpose Electrical/Electronic Test Equipment
SPETERL	Ship/Shore Portable Electrical/Electronic Test Equipment Requirements List
SPMIG	Standard PMS Materials Identification Guide
STD	Standard
STG1	Sonar Technician Surface First Class
SU	Start-Up
SUBSAFE	Submarine Safety
TD	Time-Directed
TM	Technical Manual
TMDE	Test, Measurement, and Diagnostic Equipment
TMDE-I	Test, Measurement, and Diagnostic Equipment Index
TPME	Tools, Parts, Materials, Test Equipment
UMRC	Unscheduled Maintenance Requirement Card
VOC	Volatile Organic Compound

3.2 Age.

3.2.1 Age. Age is defined as any meaningful measure of wear; for example, calendar time, starts, stops, and operating cycles are measures of wear.

3.2.2 Age degradation. A decrease in the resistance of failure of an item that occurs as the item experiences wear (as defined above).

3.2.3 Age exploration. An empirical technique that involves increasing the initial task interval by a percentage (for example, 10 percent), provided a complete and thorough inspection does not indicate any signs of aging or wear and tear. Age exploration tasks collect specific data from actual operational and test environments to replace the assumptions made during the initial RCM analysis and proactive task development efforts. Age exploration data may reveal the need to extend, shorten, establish, or eliminate proactive tasks. Age exploration is described in Appendix B of this standard.

3.2.4 Age-reliability characteristics. The characteristics exhibited by the relationship between the age of an item and its conditional probability of failure.

3.3 Class maintenance plan (CMP). The principal document for executing the approved maintenance program for all ships in a class. The CMP provides organizational-level, intermediate-level and depot-level planned maintenance action tasks. The CMP describes all preventive maintenance actions and maintenance support requirements, including material condition assessment requirements, approved modernization, and shipyard routines. CMP tasks are developed by cognizant technical authority, using RCM. CMP tasks will include or refer to fully detailed procedures for accomplishment of maintenance actions. The CMP also includes standard repairs required based on commonly expected assessment results.

3.4 Conditional probability of failure. The probability that a failure will occur in a specific period provided that the item concerned has survived to the beginning of that period.

3.5 Consequence.

3.5.1 Economic or mission consequence. A measure of the economic or mission impact due to a functional failure which results in the loss of mission essential equipment or high repair costs, and does not affect personnel safety or ship survivability.

3.5.2 Failure consequence. The measure of safety, environmental, mission, and economic impact of an item's functional failure caused by a specific failure mode.

3.5.3 Hidden failure consequence. The measure of the impact of the loss of a protective or secondary function due to the undetected failure of a hidden function.

3.5.4 Regulatory consequence. A measure of the impact of the loss of a function on the ability to comply with laws or standards.

3.5.5 Safety consequence. A measure of the direct threat to life, limb, or health of persons due to the loss of a function.

3.6 Default answer. In a binary decision process, the answer to be chosen in case of uncertainty; employed in the development of an initial preventive maintenance program to arrive at a course of action in the absence of complete information.

3.7 Development. The act of researching, examining, writing, and documenting a maintenance program.

3.8 Fail-safe system. A device or feature which, in the event of failure, responds in a way that will cause no harm or, at least, a minimum of harm to machinery or personnel.

3.9 Failure. The presence of an unsatisfactory condition that impairs functional performance. What constitutes an unsatisfactory condition must be specifically identified for each function.

3.9.1 Functional failure. The inability of an item to perform a specific function within specified limits.

3.9.2 Hidden failure. A functional failure which is not observable to the operating crew during their routine duties (within a watch, shift, etc.).

3.9.3 Potential failure. A definable and measurable condition that indicates a functional failure is imminent.

3.10 Failure cause. The underlying stimulant of the failure or the root process which leads to failure, including defects in design, process, quality, maintenance, or part application.

3.11 Failure effects. Failure effects describe what happens when a failure mode occurs if no other action is taken to otherwise address the failure.

3.12 Failure mode. The specific condition causing a functional failure (often best described by the material condition at the point of failure).

3.12.1 Dominant failure mode. A cause of failure that is important because of a high probability and severity or high probability or severity of the failure. With respect to probability, a dominant failure mode has a high probability of repeated occurrence over the life of a single system or the highest probability of a single occurrence for many individual systems among a fleet of assets.

3.13 Function. Any action or operation which an item is intended to perform.

3.13.1 Active function. A function provided by activity of an item.

3.13.2 Evident function. A function provided by an item whose loss is observable to the operating crew during the performance of their routine duties.

3.13.3 Hidden function. A function provided by an item for which there is no immediate indication of malfunction or failure. The demand for such functions usually follows another failure or unexpected event.

3.13.4 Passive function. A function that does not require activity of an item.

3.14 Indenture level. A level of relative importance in a hierarchical set. The levels progress from the general to the specific.

3.15 Item.

3.15.1 End item. An assembly of hardware elements that is not used to assemble a higher level physical item, and is ready for its intended use.

3.15.2 Functionally significant item (FSI). An item whose functional failure has safety, statutory, regulatory, mission, or major economic consequences.

3.16 Maintenance. Actions taken to ensure components, equipment, subsystems, and systems provide their intended functions when required.

3.16.1 Alterative maintenance. Modification to existing design of a component, equipment, subsystem or system to improve safety or reliability. Alterative maintenance can also modify existing design to enable an applicable and effective preventive maintenance task.

3.16.2 Condition based maintenance (CBM). A maintenance strategy based on equipment operational experience derived from analysis. CBM includes maintenance processes and capabilities derived from real-time or approximate real-time assessments obtained from embedded sensors or external tests and measurements using either portable equipment or actual inspection. The objective of CBM is to perform maintenance based on the evidence of need while ensuring safety, reliability, availability, and reduced total ownership cost.

3.16.3 Condition based maintenance plus (CBM+). The application and integration of appropriate processes, technologies, and knowledge-based capabilities to achieve the target availability, reliability, and operation and support costs of DoD systems and components across their life cycle. At its core, CBM+ is maintenance performed based on evidence of need, integrating RCM analysis with those enabling processes, technologies, and capabilities that enhance the readiness and maintenance effectiveness of DoD systems and components. CBM+ uses a systems engineering approach to collect data, enable analysis, and support the decision-making processes for system acquisition, modernization, sustainment, and operations. RCM relationship with CBM+ technologies is discussed in Appendix F.

3.16.4 Corrective maintenance. A maintenance task performed to identify, isolate, and rectify a fault so that the failed equipment, component, subsystem, or system can be restored to an operational condition within the tolerances or limits established for in-service operations.

3.16.5 Inactive equipment maintenance (IEM). Tasks performed to establish, maintain, and restore components, equipment, subsystem, or system in a lay-up status to ensure it is fully operational when it is returned to service.

3.16.6 Lay-up maintenance. Tasks performed to prepare components, equipment, subsystem, or system for a period of inactivity.

3.16.7 Planned maintenance. A maintenance task whose parts and procedures have been pre-defined in anticipation of having to perform the maintenance task in the future. Maintenance carried out according to a fixed and standardized plan.

3.16.8 Preventive maintenance. An action that reduces the probability of occurrence of a particular failure mode, or discovers a hidden failure.

3.16.9 Reliability-centered maintenance (RCM). A method for determining maintenance requirements based on the analysis of the likely functional failures of components, equipment, subsystems, or systems having a significant impact on safety, operations, and life cycle cost. RCM supports the failure-management strategy for any component, equipment, subsystem or system based on its inherent reliability and operating context.

3.16.10 Situational maintenance. Tasks performed when triggered by a specific event (or situation) or equipment state.

3.16.11 Start-up maintenance. Tasks performed to prepare equipment for operation after a period of inactivity.

3.16.12 Unscheduled maintenance. Actions performed when triggered by other scheduled maintenance actions, failures, or repair requirements.

3.17 Maintenance coordinating activity (MCA). Government activity which funds, authorizes, manages, monitors, or coordinates maintenance management documentation developed by commercial contractors and In-Service Engineering Agents (ISEAs), etc. The MCA has review authority for all phases of RCM development.

3.18 Maintenance development activity (MDA). Activity (commercial contractors, ISEAs, NAVSEA field activities, etc.) which develop maintenance documentation. The MDA is the activity to which the maintenance developer is assigned.

3.19 Master system and subsystem index (MSSI). Documents the hierarchical breakdown of a development.

3.20 Materiel. Any item which can be classified as a component, equipment, subsystem, or system.

3.21 Periodicity. Delineates how frequently the maintenance requirement must be performed.

3.22 Protective device. Components, equipment, or design characteristics installed to reduce or prevent equipment damage in the event of a failure.

3.23 Redundancy. The design practice of duplicating the sources of a function so that the function remains available in the same quality and quantity required after the failure of one or more items. Redundancy can be designed into any indentured level.

3.24 Reliability. The probability that an item will perform its intended function for a specified interval under stated conditions.

3.25 Repair part. Any item that is an integral part of the equipment, is listed in a technical manual or drawing parts list, and appears on an Allowance Parts List (APL).

3.26 Safety feature. Components, equipment, subsystems, systems, or design characteristics included to reduce or prevent personnel injury or death in the event of a failure.

3.27 Spare part. Any part, component, or subassembly kept in reserve for maintenance or repair.

3.28 Task.

3.28.1 Applicable task. A task which discovers, prevents, or reduces the impact of a failure mode.

3.28.2 Condition-directed (CD) task. CD tasks are periodic tests or inspections to compare the existing conditions or performance of an item with established standards to determine the need for a follow-on renewal, restoration, or repair to prevent the loss of function.

3.28.3 Effective task. A task which reduces the risk of the occurrence or economic impact of a failure to an acceptable level based on the consequences of failure.

3.28.4 Failure-finding task. A test or inspection performed at a specified interval to determine whether equipment providing a hidden function has failed.

3.28.5 Lubrication task. A task that adds or replenishes a lubrication film (oil or grease) that exists solely to reduce the wear that results from the friction of two surfaces moving in relation to one another.

3.28.6 Servicing task. The replenishment of consumable materials that are depleted during normal operations. Mechanical filter maintenance, replenishment through cleaning or replacement (for example, air, oil, and water) may be included as a servicing task.

3.28.7 Time-directed (TD) task. Task performed at a specified interval without consideration of other variables. This interval may be based on calendar, operation, or number of recurring events, etc.

4. GENERAL REQUIREMENTS

4.1 Interpretation of the word "ship". For the purpose of this standard, the term "ship" shall be interpreted as submarines, surface ships, aircraft carriers, and craft.

4.2 Security classification. The security classification of materials to be used in maintenance requirements development shall be governed by OPNAVINST 5513.1 (series) security classification guides. OPNAVINST 5513.1 (series) is based upon the program, project, weapon, or ship for which maintenance requirements are being prepared. Security classification shall be based on data actually extracted for the maintenance rather than the overall classification of the source document (see 6.2). Inquiries concerning appropriate security classification or markings should be referred to the Commander, Naval Sea Systems Command (COMNAVSEASYSCOM).

4.3 Certification requirements. Maintenance developers using the RCM methodology contained in this standard shall be Naval Sea Systems Command (NAVSEA) RCM certified. NAVSEA certification requirements are described in NAVSEAINST 4790.8 (series), OPNAVINST 4700.7 (series), and NAVSEAINST 4790.27 (series). NAVSEA will not accept RCM analysis packages from anyone not NAVSEA RCM certified. Certification training information can be obtained from the Maintenance Coordinating Activity (MCA).

4.3.1 Classic RCM certification. Persons who develop, review, verify, or approve new maintenance requirements for NAVSEA shall be NAVSEA RCM Level Two (Classic RCM) certified. Classic RCM methodology shall be used in determining maintenance requirements for new systems, subsystems, and equipment during ship acquisition and as the ship class is modernized during its cycle. The Classic RCM process is detailed in section five of this standard.

4.3.2 Backfit RCM certification. Persons who review, modify, plan, or approve changes to existing approved maintenance requirements for NAVSEA shall be NAVSEA RCM Level One (Backfit RCM) certified. Backfit RCM shall only be applied on existing approved maintenance requirements. The Backfit RCM process is detailed in Appendix D.

4.4 Maintenance requirements. Maintenance requirements shall be developed using the RCM methodology as specified herein. The contractual documents for maintenance requirements shall include the name and address of the MCA which will coordinate the development and preparation of the maintenance documentation. NAVSEA will designate the MCA. Corrective maintenance task identification (Phase 8) will only be accomplished when specified and directed by the acquisition document. Figure 1 depicts the relationship between the MDA and the MCA for development of maintenance requirements using the RCM methodology contained in this standard. Figure 1 depicts the required review and approval points in the analysis process. This workflow shall be used by anyone developing maintenance requirements in the process of submitting deliverable RCM analysis packages to NAVSEA. The MCA, as designated by NAVSEA, shall determine the conformance of the deliverable items to the requirements of this standard (see 6.2). Appendix A consists of sample forms to indicate the data to be provided as called out in the Data Item Descriptions (DIDs) for different phases of RCM covered by this standard. Appendix F depicts the relationship between RCM and CBM+ technologies.

4.4.1 Classic RCM maintenance requirements. Classic RCM (Level Two) shall be applied in determining maintenance requirements for new systems, subsystems, and equipment during ship acquisition and as the ship class is modernized during its life cycle. The Classic RCM methodology is contained in section five.

4.4.2 Backfit RCM maintenance requirements. Backfit RCM (Level One) shall only be applied on existing approved maintenance requirements. The Backfit RCM methodology is contained in Appendix D.

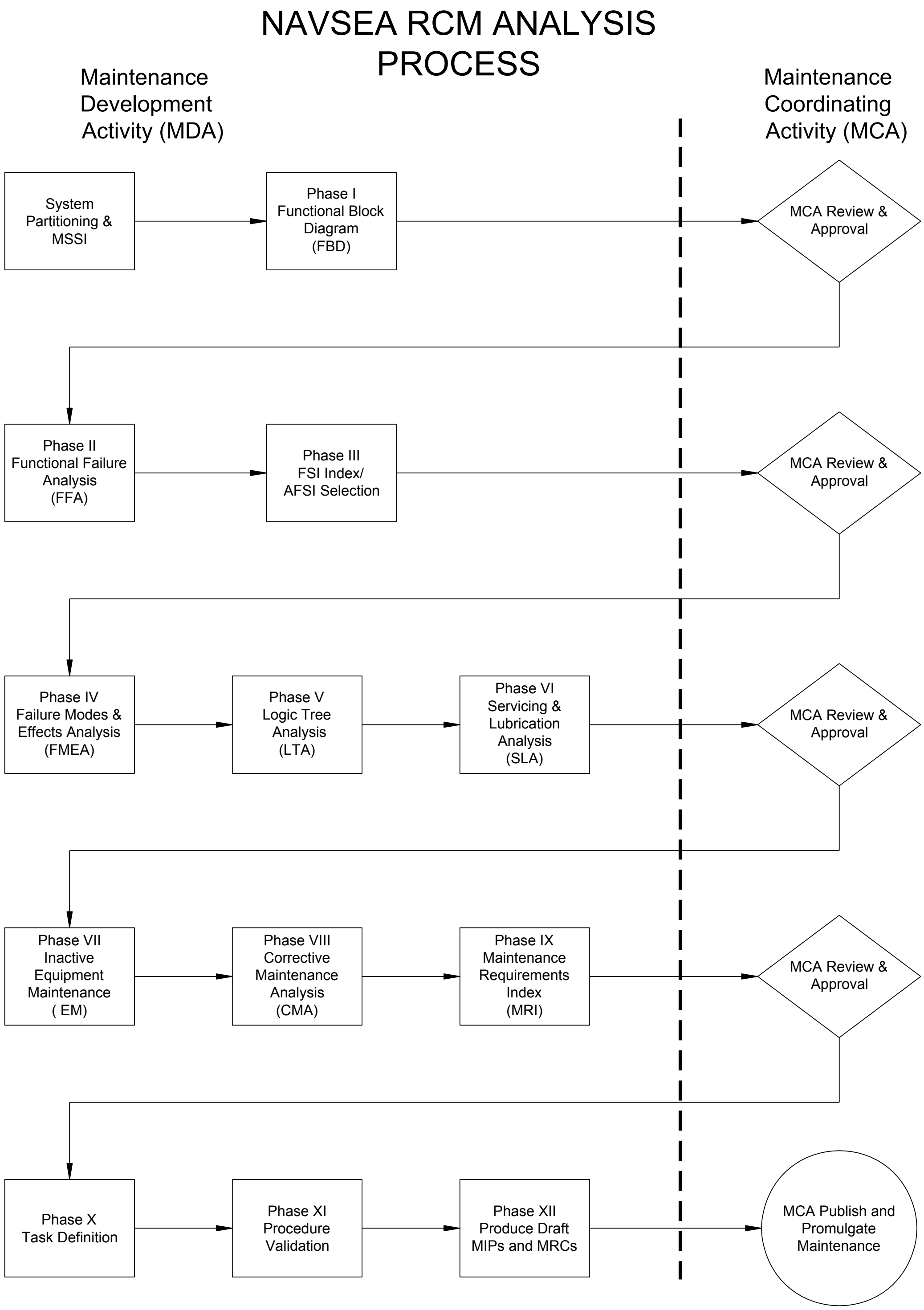

FIGURE 1. NAVSEA classic RCM analysis process.

5. DETAILED REQUIREMENTS

5.1 Classic RCM process. Classic RCM is the process used to determine the maintenance strategy and requirements for new and in-service components, equipment, subsystems, or systems. The process described in this standard supports the DoD Condition Based Maintenance (CBM+) policy as described in DoDI 4151.22 and complies with the RCM criteria published in the DoD RCM Manual (DoD 4151.22M). The RCM process is composed of up to twelve phases. RCM development in structured phases ensures that every maintenance action specified in a maintenance package can be justified in accordance with the fundamental RCM principles used by both DoD and commercial entities.

The initial maintenance package provides the baseline for system expectations. As operational experience is developed (for example, failure data, inspection results), the maintenance package will be monitored and improved as required.

Materiel may be delivered with recommended maintenance tasks that were not developed using RCM. These tasks shall only be included after they have been evaluated by the RCM process and found to be applicable and effective.

RCM development shall be accomplished in phases as specified (see 6.2). The twelve phases of the RCM development process are:

a. Phase 1 – System partitioning and functional block diagram (FBD). Partitioning along major system and subsystem boundaries to facilitate analysis and specify analysis boundaries (scope) and approach (see 5.1.1).

b. Phase 2 – Functional failure analysis (FFA). Analysis of the functions of systems and subsystems and of the ways in which those functions can fail (see 5.1.2).

c. Phase 3 – Functionally significant item (FSI) index and additional functionally significant item (AFSI) selection. This is the phase where FSIs and AFSIs, if applicable, are identified (see 5.1.3).

d. Phase 4 – Failure modes and effects analysis (FMEA). Analysis of the failure modes and effects of failure of the FSIs (see 5.1.4).

e. Phase 5 – Decision logic tree analysis (LTA) (see 5.1.5).

f. Phase 6 – Servicing and lubrication analysis. Analysis of servicing and lubrication task requirements (see 5.1.6).

g. Phase 7 – Inactive equipment maintenance (IEM) task identification (see 5.1.7).

h. Phase 8 – Corrective maintenance task identification (see 5.1.8).

i. Phase 9 – Maintenance requirements index (MRI) (see 5.1.9).

j. Phase 10 – Maintenance requirement task definition (see 5.1.10).

k. Phase 11 – Maintenance procedure validation (see 5.1.11).

l. Phase 12 – Maintenance requirement card (MRC) and maintenance index page (MIP). Development and preparation of MRCs and formulation into MIPs (see 5.1.12).

5.1.1 RCM phase 1 – system partitioning and functional block diagram (FBD). The assigned boundaries of an RCM analysis may encompass anywhere from a single sub-assembly to an entire subsystem. Large multi-subsystem assignments are typically split along boundaries as defined in the Expanded Ships Work Breakdown Structure (ESWBS) before beginning the detailed RCM analysis. NAVSEAINST 4790.1 provides detailed information on ESWBS. This level of partitioning is typically accomplished at the programmatic level. Care must be taken when defining what the boundaries of a single development will encompass so that no items are forgotten or are covered within multiple developments (see figure 2). The RCM process, as described in Phases 1 through 12, is usually performed within a boundary that encompasses, at most, a single subsystem. Within this process the assigned developer(s) may still find it advantageous to subdivide the subsystem to simplify the analysis. This hierarchical approach to dividing subsystems enables the identification of an optimum level for the actual performance of the RCM process steps (see 6.2).

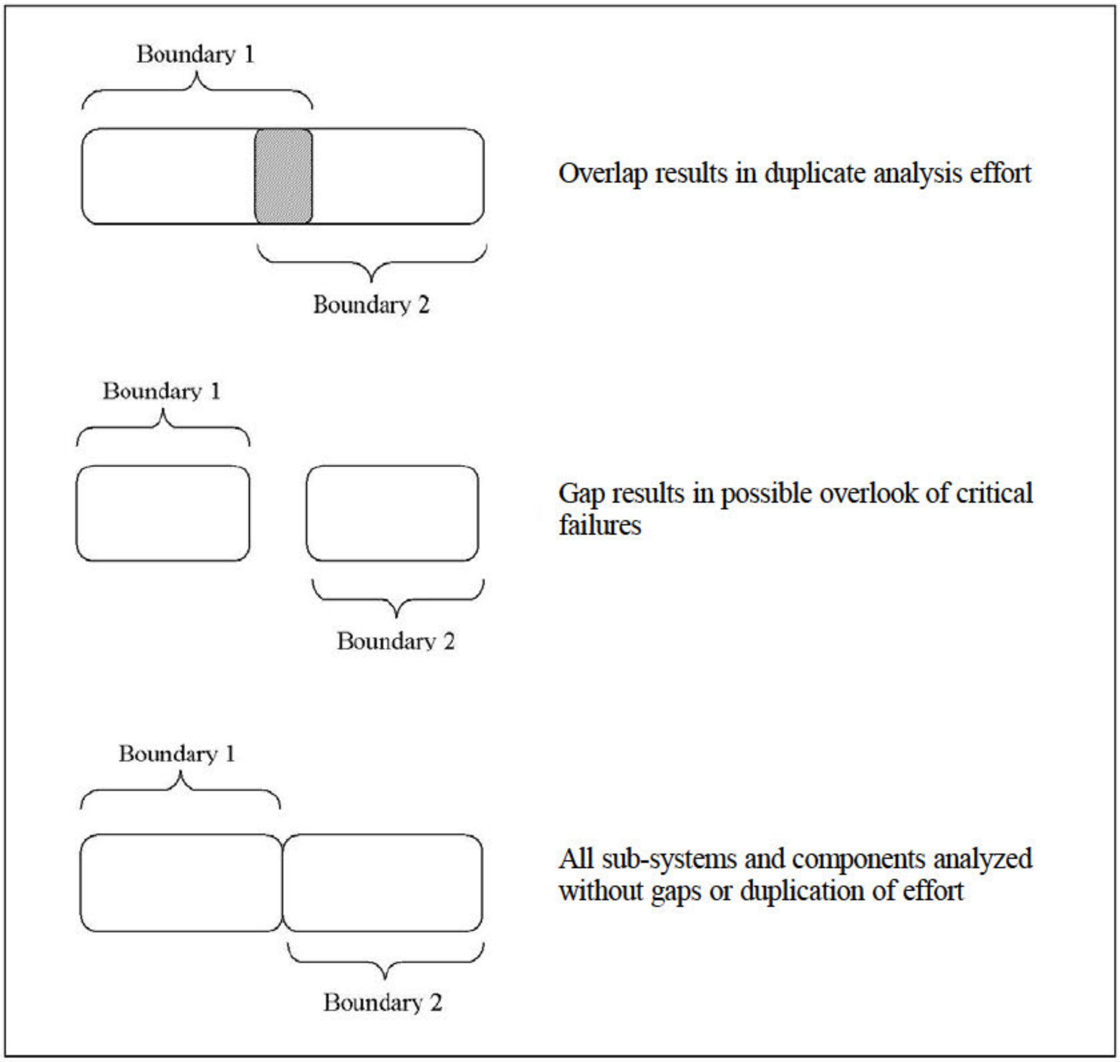

FIGURE 2. Partition boundary considerations.

In general, an analysis performed at too high a level tends to omit important functions, which causes the failure modes that impact those functions to be overlooked. This often results in gaps in the maintenance program. An analysis performed at too low a level makes it difficult to identify meaningful functions and associated performance standards. This complicates the analysis process and often results in the identification of trivial failure modes and unnecessary maintenance actions. Careful thought should be put into deciding what the optimal level is for the performance of the RCM analysis such that the number of failure modes that will be identified and the assessment of their consequences and required actions are manageable.

Both the ESWBS and the Hierarchical Structure Codes (HSC) provide a method to integrate design, configuration, and logistics standard coding of the breakdown structure for aircraft carriers, submarines, surface combatants, and associated ship systems. ESWBS provides an indentured listing of all systems, subsystems, equipment, and components with the highest level of indenture defined along major functional lines (see table I and table II). Figure 3 illustrates a typical ESWBS breakdown.

TABLE I. ESWBS functional groups.

ESWBS group number	Functional group nomenclature
100	Hull structure group
200	Propulsion plant group
300	Electrical plant group
400	Command and surveillance group
500	Auxiliary group
600	Outfit and furnishings, general
700	Armament group
800	Integration/engineering

Successive levels of indenture break each major functional group into major sub-groups (ESWBS Level II), systems (Level III), and subsystem/component boundaries (Level IV and lower).

TABLE II. Example ESWBS breakdown.

ESWBS indenture level	ESWBS number	ESWBS nomenclature
Level I	400	Command and surveillance, general
Level II	440	Exterior communications
Level III	441	Radio systems
Level IV	4413	T-1322()/SRC Communications Transmitter
Level V	44131	AM-6675/URT Amplifier

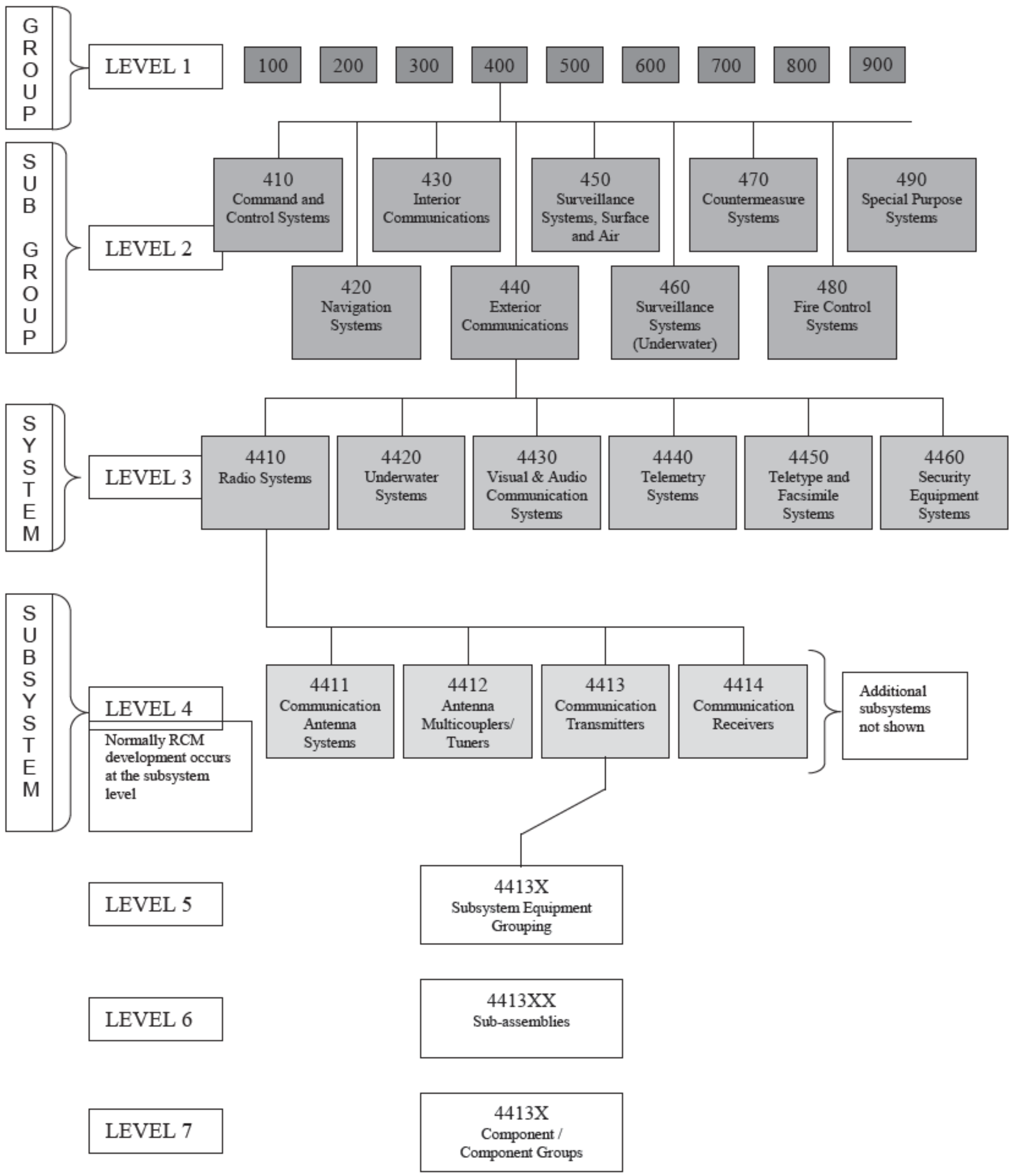

FIGURE 3. Illustrated ESWBS breakdown.

5.1.1.1 Level of development. RCM analysis should take place at a level that makes the identification of functions, failure modes, consequences, and actions meaningful and manageable. This standard is typically met when the indenture level assigned for a development focuses on a single equipment procurement subsystem as defined by the HSC Functional Group Code (FGC) and will be referred to throughout this publication as ESWBS (ESWBS group level 4). Assignment for development at ESWBS group levels above 4 (1, 2, or 3) typically results in boundaries that are too complex to manage all the associated functions, failure modes, and actions adequately. Only on rare occasions should analysis occur at ESWBS indenture level 3 or above without further indenturing within the Master Systems and Subsystems Index (MSSI) (that is, indenture level 4 or below). Once ESWBS group 4 is reached on the MSSI, indenturing more than one, or in some cases, two more levels rapidly results in analysis at too low a level as discussed earlier. For indenturing past the subsystem level (ESWBS indenture level 4) the hierarchical structure of the ESWBS is abandoned in favor of a hierarchical structure unique to the development (see table III).

Maintenance is typically developed for an entire subsystem.

TABLE III. Partitioning example of two subsystem equipment groupings.

ESWBS manual	Nomenclature	Development hierarchy
100	Major functional group	100
120	Functional subgroup	120
123	System functional group	123
1234	Subsystem	1234
1234X	Subsystem equipment group (A)	1234A
	Sub-assembly	1234AA
	Component	1234AAA
1234X	Subsystem equipment group (B)	1234B
	Sub-assembly	1234BA
	Component	1234BAA

5.1.1.2 Documenting analysis boundaries and subdivisions. Boundary documentation consists of the FBD and the MSSI. The developer shall secure or prepare an FBD encompassing the entire assigned development boundary. The MSSI documents the development hierarchical breakdown approach used to identify the system functional group, the assigned subsystem boundaries, and relationships to lower indentured equipment, assemblies, and components. Along with the FBD, the MSSI provides an outline for the analysis.

When the developer(s) decides to subdivide the assigned indenture level into smaller subsystems, the MSSI is expanded to document the hierarchical approach used to subdivide the subsystem. In addition, each new indenture level shall have an FBD that identifies its boundaries in relation to the subsystem. Each of the subdivisions is, by definition, an indenture level of the assigned development. Each of the identified indenture levels shall be analyzed separately during the RCM process. Unique failure modes shall be analyzed at the lowest indenture level where they occur (for example, for a fluid flow system, the pumps are also defined as their own level of indenture. While pumps are part of the higher system, items unique to the pump are only addressed once at the pump level analysis. The system level will then address everything except the failure modes for the pumps which have already been covered at the lower level.).

Determining level of partitioning and detail should be agreed upon with the MCA prior to finalizing the block diagram layout.

5.1.1.3 Functional block diagrams (DI-SESS-80994). The format of the FBD shall be orderly but unrestrictive. When approved by the MCA, system schematics or line drawings reproduced from appropriate technical manuals or ship information books may be used with applicable additions and annotations. The entire FBD shall be enclosed by a dashed line signifying the system boundary.

The FBD shall display all components of the subsystem, their functional relationships to one another, and in and out interfaces with other subsystems. Generally, some components of a subsystem, although identified separately, may actually be grouped together to form higher assemblies. Assemblies may be appropriately labeled as a single box on the FBD. Label components and assemblies in the subsystem by their common name, including generic name, MK, MOD, and AN nomenclature or other identifier. Hardware such as switchboards or valve manifolds, that are not actually part of the system under analysis, may be included to simplify the diagram and to enhance meaningfulness. Such hardware may be identified by descriptor or nomenclature including assigned ESWBS number.

The components and assemblies of a subsystem are connected to each other and interface with other subsystems through electrical, fluid, gas, or mechanical linkages. Linkages on the FBD shall be shown as heavy lines. Each connection shall identify the connection and the normal parameter value or range of values. In addition to parameter labels, interface connections shall be labeled with the ESWBS number of the system, subsystem, or equipment from which the connection originates or which receives the out interfaces. Flow directional arrows shall be required on connection lines. Sensors and gages that monitor functional parameters should be included within the FBD, along with the parameter that is monitored.

5.1.1.4 Completing MSSI data collection (DI-SESS-80979/figure A-1).

a. Block 1 – ESWBS group number. Enter the ESWBS group level 1 number, a three-digit number containing two zeroes.

b. Block 2 – Group nomenclature. Enter the associated group nomenclature.

c. Block 3 – Ship class. Enter the ship class and the hull number on which the analysis is based.

d. Block 4 – Prepared by. Enter the analyst's name and the date.

e. Block 5 – Reviewed by. Reserved for first level reviewer's approval signature and date.

f. Block 6 – Approved by. Reserved for MCA approval signature and date.

g. Block 7 – Revision. Enter ORIGINAL, or A, B, or C, sequentially, and the date.

h. Block 8 – ESWBS subgroup/system/subsystem number. Enter a number identifying each subdivision through ESWBS level 4. If the level 4 ESWBS number cannot uniquely identify the subsystem specified for development, or the developer wishes to further divide the subsystem to enhance development, add a suffix character to the level 4 ESWBS to create a development specific hierarchical structure.

i. Block 9 – Subgroup/system/subsystem nomenclature. Enter the nomenclature of each ESWBS subdivision identified.

j. Block 10 – Serial number. Enter a serial number for this form as follows:

(1) Segment 1 – enter the developing organization abbreviation, followed by a slant (/).

(2) Segment 2 – for developers, enter the development authorization number, followed by a slant (/); for other development activities, assign a development number followed by a slant (/).

(3) Segment 3 – enter the number "114" to indicate the MSSI form, followed by a slant (/).

(4) Segment 4 – enter the highest indenture level ESWBS for the development group assigned. If an entire group is assigned, this number is a level 1 ESWBS number – a three-digit number containing two zeroes; for example, "100", "200".

5.1.1.5 Submission to MCA. Upon completion of Phase 1, the developer will submit the FBD and MSSI to the MCA for approval with consideration to the following:

a. Boundaries appropriate for the analysis.

b. Approach for subdividing within the assigned boundary.

(1) Single indenture for subsystem level.

(2) Multiple indentures at both the subsystem and subsystem equipment/component levels.

c. Adequacy of the associated FBD(s).

5.1.2 Phase 2 – functional failure analysis (FFA). Following approval of Phase 1 and at the direction of the maintenance coordinating activity, the developer shall perform an FFA at the same and lower level of subsystem being analyzed as defined by the MSSI.

5.1.2.1 Purpose of the FFA. The FFA is performed to determine and to document:

a. A functional description of the system or subsystem including protective features, installed monitoring and testing devices, redundancy provided, and any other information associated with the maintenance needs of the system and visibility of failures.

b. The specific functions of the system.

c. The interfaces of the system or subsystem with other systems.

d. The functional failures of the system or subsystem.

5.1.2.2 FFA preparation guidelines. The FFA, when completed, shall describe the characteristics of the subsystem that must be considered for potential preventive maintenance tasks. If the MSSI identifies multiple subsystem equipment groupings (that is, multiple indenture levels), an FFA shall be completed for each subsystem equipment grouping.

The FBDs from Phase 1, technical manuals, and other pertinent references shall be used as the basis for the FFA.

5.1.2.2.1 FFA information gathering. FFA information gathering should focus on what the equipment does at the specific indenture level addressing the installed configuration and required applications. The description should be developed in conjunction with a thorough investigation of equipment requirements. The discovery process should provide the developer with a detailed understanding of the equipment including:

a. How the equipment is installed and how the installation may affect reliability.

b. How the equipment is to be used and operated.

c. Design features of the equipment which improve reliability, safety, or maintainability.

d. Identify design parameters such as set-points and tolerances.

e. Identify prognostic and diagnostic sensor capabilities that support maintainability.

Special attention should be given to discovering things about the equipment that could influence the decision process for maintenance development.

Investigate if some degree of redundancy has been designed into the subsystem. Redundancy exists when the function in question can be obtained in the same quality and quantity following functional failure. Redundancy provides increased system availability. Redundancy is evaluated within the boundaries of the FBD.

5.1.2.2.2 Functions. Maintenance is intended to preserve the required functions of a subsystem. A fundamental step, therefore, is to ensure that all functions of the subsystem are identified, and documented. A subsystem may provide a function by providing information, providing flow and pressure of a fluid, or converting stored energy to motion. Functions of this type are called "active functions" because they provide a commodity or stimulus as an output. Loss or degradation of that activity is a functional failure. A subsystem may also provide a function by not doing something actively, such as a tank holding fluid. Functions of this type are called "passive functions" because they are inactive. An event such as a leak in the tank is a functional failure. When a function fails, alarms or performance of the system may alert the operating crew immediately that the function has been lost. This type of function is called an evident or visible function since its loss is visible to the crew. Functions that give no immediate indication that they have failed are called hidden functions. *Hidden functions may require a special procedure to determine if the function is available*. In a combatant ship, some systems are infrequently used (for example, missile launcher, oxygen breathing apparatus). The functions of these infrequently used systems are hidden functions. Some systems have co-functions, which are functions that are physically or environmentally closely associated. Failures in one function will adversely affect other functions, even though these functions are normally independent. All functions of the system shall be determined and documented. Document all functions of the subsystem including:

a. Functions of safety and protective devices.

b. Required outputs of the subsystem (primary functions).

c. Any secondary functional requirements of the subsystem such as:

(1) Environmental integrity (threat to environment).

(2) Structural integrity (structurally significant items).

(3) Containment.

5.1.2.2.3 Interfaces. Subsystems usually receive input from other subsystems and provide output to other subsystems. Loss of input can cause failure in the subsystem and loss of output can cause failure in other subsystems. Subsystem interfaces are addressed separately in the FFA process because they are easily overlooked and vary widely for different configurations of the same basic subsystem. "In" interfaces shall be assumed available. "Out" interfaces shall be identified as functions.

5.1.2.2.4 Functional failures. A functional failure exists when a system or subsystem ceases to provide a required function; whether the function is active, passive, evident, or hidden. The definition of what constitutes a failure is of primary importance. Whenever a failure is defined by some level of performance, condition, or dimension, the appropriate standards must be stated to provide the basis for establishing whether a failure has occurred. Where applicable, these definitions of failures in terms of system parameters or performance standards are required. When defining functional failures or functions provided by redundant items, the failure shall be clearly defined as a failure of all redundant items.

5.1.2.2.5 Documenting the functional failure analysis (DI-SESS-80981/figure A-2). The FFA data form shall comprise the following:

a. Block 1 – ESWBS number. Duplicate the relevant entry from the MSSI form, block 8.

b. Block 2 – Nomenclature. Enter the nomenclature used on the MSSI form, block 9, for the selected system or subsystem.

c. Block 3 – Ship class. Duplicate the entries on the MSSI form, block 3.

d. Block 4 – Prepared by. Enter the analyst's name and the date.

e. Block 5 – Reviewed by. Enter the first level reviewer's name and the date.

f. Block 6 – Approved by. Reserved for MCA approval signature and the date.

g. Block 7 – Revision. Enter ORIGINAL, or A, B, or C, sequentially, and the date.

h. Block 8 – Sources of information. Enter the drawing, manual, document, and report numbers. Enter titles of reference material used in this analysis.

i. Block 9 – Description. Referring to the FBD prepared in Phase 1, enter a brief physical and functional description of the subdivision. Focus on what the hardware is and how it functions, oriented toward preventive maintenance needs. After this narrative, document the following specific information about the system using the format below (parenthetical statements describe the information to be documented):

(1) Redundancy: Enter "NONE", or describe the redundant relationship.

(2) Protective devices: List the protective devices and the circumstances under which they operate; for example, "Circuit breaker – 30 AMP", "Casing relief valve – lifts at 150 pounds per square inch (lb/in^2), reseats at 135 lb/in^2".

(3) Safety features: Describe special safety features such as interlocks.

(4) Fail-safe features: State whether system has a fail-safe feature. Describe any fail-safe features.

(5) Condition indicators: Document type, indicates, and to whom in a single group for each indicator as follows:

(a) Type: Enter gage, thermometer, meter, indicator light, audible visual alarms, as appropriate.

(b) Indicates: Describe what the indicator tells about the system.

(c) To whom: List the watch station or the title of the operator who observes the indicator. Specify the conditions when that station is manned.

(6) Environment: Describe the environment to which the system is exposed; for example, "Exposed to weather", "Exposed to high humidity", "Exposed to high heat", or other.

(7) Duty cycle: Describe the particulars of normal operational practices and estimated operational time per year. For example, "The system is normally on line when underway and is automatically controlled.", "Air compressors cycle on and off under control of associated receiver pressure switches. Compressors run about 250 hours per year, depending on demand."

(8) Use restrictions: Enter any special restrictions on the operation of the system; for example, "Cannot be safely activated in port".

(9) Special maintenance features: Describe any special provisions for maintenance installed, such as built-in test equipment (BITE); for example, "System is equipped with external test connections enabling full diagnostic while on line."

(10) Regulatory: Enter "NONE" or describe any regulations [for example, Environmental Protection Agency (EPA), Occupational Safety and Health Administration (OSHA)] requiring the performance of maintenance or any regulations which may be violated if a failure occurs.

j. Block 10 – Functions and out interfaces. Enter a description of the functions of the system. Include safety, regulatory, and protective features, out interfaces, and all co-functions. State function minimum operational parameters or performance standards, if appropriate. Number functions sequentially; for example, "1.0", "2.0", and "3.0".

k. Block 11 – System in interfaces. Enter sources of input and critical values. Specify the ESWBS number for each source.

l. Block 12 – Functional failures. Enter the definition of what constitutes a failure for each function and output interface listed in block 10. There may be several functional failures for each function; all functional failures must be identified. Number each functional failure (for example, 1.1, 1.2, 1.3, 2.1, 2.2, and 2.3) to correspond to the function number in block 10.

m. Block 13 – Serial number. Enter a four-segment serial number as follows:

(1) Segment 1 – see 5.1.1.4.j(1).

(2) Segment 2 – see 5.1.1.4.j(2).

(3) Segment 3 – enter the number "116", indicating the FFA form, followed by a slant (/).

(4) Segment 4 – enter the ESWBS number from block 1.

5.1.3 Phase 3 – functionally significant item (FSI) index and additional functionally significant item (AFSI) selection. Items listed at or below the assigned indenture level on the MSSI are FSIs. AFSIs (see 5.1.3.4) are also treated as FSIs. In the case of simple subsystems, it is sometimes practical to consider an entire subsystem as the only FSI. Ultimately, an FMEA will be required for each FSI. FSIs should be selected at such a level that the FMEA is meaningful and simple. The developer shall prepare the additional FSI selection forms for items considered to be candidates for selection as AFSIs. Careful review of the system block diagram is required to determine which of the following approaches will be used:

a. A single FSI for the entire subsystem.

b. FSIs assigned at subsystem and equipment grouping level, but not to equipment sub-assemblies.

c. FSIs can sometimes be assigned at sub-assembly levels and subsystem levels. This approach permits "hybrid" solutions; for example, relatively few subsystem equipment groupings may be considered for selection as AFSIs. The functions and failures of items not selected as AFSIs are considered in the analysis of the related subsystem.

5.1.3.1 Beginning RCM analysis at phase 3. The maintenance coordinating activity may authorize RCM analysis to begin at Phase 3 (that is, bypassing the FBD and FFA). Beginning RCM analysis at Phase 3 is advantageous when alterations are installed on an existing subsystem, current materiel is repurposed, or the materiel is a self-contained unit. FSIs that may have been overlooked in the FBD or FFA may be designated for beginning RCM analysis at Phase 3.

5.1.3.2 Functionally significant item (FSI) index. The FSI index is required for each RCM analysis. This index delineates the FSIs that will form the basis of the failure modes and effects analysis (Phase 4).

5.1.3.3 Completing the FSI index form (DI-SESS-80982A/figure A-4). The FSI index form will be completed as follows:

a. Block 1 – System/subsystem ESWBS number. Enter the highest level ESWBS number to be covered by the index.

b. Block 2 – System/subsystem nomenclature. Enter the associated system/subsystem nomenclature for the ESWBS number specified in block 1.

c. Block 3 – Ship class. Enter the ship class and hull number to which the analysis applies.

d. Block 4 – Prepared by. See instructions for the MSSI form.

e. Block 5 – Reviewed by. See instructions for the MSSI form.

f. Block 6 – Approved by. See instructions for the MSSI form.

g. Block 7 – Revision. See instructions for the MSSI form in 5.1.1.4.g.

e. Block 8 – ESWBS number. Duplicate the entry on each FFA form, block 1, and each AFSI selection form, block 1, that had a "YES" in block 15.

f. Block 9 – Nomenclature. Duplicate the entry on each FFA form, block 2, or AFSI selection form, block 2.

g. Block 10 – Location. Duplicate the entries in block 9 of the AFSI selection form for the item (equipment only).

h. Block 11 – Serial number. Enter a four-segment serial number as follows:

(1) Segment 1 – see 5.1.1.4.j(1).

(2) Segment 2 – see 5.1.1.4.j(2).

(3) Segment 3 – enter the number "118", indicating the FSI index form, followed by a slant (/).

(4) Segment 4 – enter the ESWBS number from block 1.

5.1.3.4 Additional functionally significant item (AFSI) selection. AFSIs may be selected by this analysis. The AFSI selection process identifies items other than the entire system or subsystem that merit separate analysis because of their importance or complexity. This process determines and documents a brief description of the candidate AFSIs similar to that prepared in subsystem and lower indentured level FFAs. The functions and functional failures of the AFSI are determined and listed specifying values of parameters or performance standards where applicable. A series of yes or no questions, based on the analyst's judgment of the FSI in question, are used to determine the validity of the analyst's decision. Equipment and repairable or replaceable assemblies are potential candidates.

5.1.3.5 Completing the AFSI selection form (DI-SESS-80983/figure A-3). When a candidate AFSI is identified, the AFSI data shall be completed as follows:

a. Block 1 – ESWBS number. Enter the ESWBS number for the FSI candidate. If the candidate is below level 4 and does not have a unique ESWBS number, add a suffix character to the level 4 ESWBS number and use this throughout the analysis.

b. Block 2 – Nomenclature AFSI candidate. Enter the nomenclature of the AFSI candidate. Nomenclature without military designation should include Commercial and Government Entity (CAGE) code, part number, and proper name as extracted from drawings or technical manuals.

c. Block 3 – Ship class. Enter the ship class and the hull number on which the analysis is based.

d. Block 4 – Prepared by, block 5 – Reviewed by, block 6 – Approved by, and block 7 – Revision. See instructions for the MSSI form in 5.1.1.4.

e. Block 8 – Description. Enter a brief functional description of this item keyed to its maintenance needs and provisions for maintenance. After this narrative, document the following specific information about the system:

(1) Redundancy: Enter "NONE" or describe a redundant relationship.

(2) Interfaces: Enter "NONE" or identify sources of input and critical values. Specify the ESWBS number for each source.

(3) Built-In Test Equipment (BITE): Enter "NONE" or describe the BITE.

(4) Regulatory: Enter "NONE" or describe any regulations (for example, EPA, OSHA) requiring the performance of maintenance or any regulations which may be violated if a failure occurs.

(5) Indicators: Enter "NONE" or document for each indicator:

(a) Indication: Describe what the indicator tells about the system.

(b) To whom: List the watch station or the title of the operator who observes the indicator.

(c) Conditions when observed: Specify the conditions when the watch station is manned or the indication is observed.

f. Block 9 – Location. Enter the compartment numbers of spaces where this item is located.

g. Block 10 – Quantity. Enter the quantity of items installed in this system.

h. Block 11 – Function(s). Enter a description of the functions of the system. Include safety, regulatory, and protective features, out interfaces, and all co-functions. State function minimum operational parameters or performance standards, if appropriate. Number functions sequentially; for example, "1.0", "2.0", and "3.0". Under the Impact column, block 11a, enter a "yes" or "no" in answer to the question, "Are any of these functions necessary for safety, mobility, or mission?"

i. Block 12 – Functional failures. Enter the definition of the failure for each of the functions listed in block 11. Number each 1.1, 1.2, 1.3, 2.1, 2.2, and 2.3 corresponding to the appropriate function. Under the Impact column, block 12a, enter a "yes" or "no" in answer to the question, "Do any of these failures have a direct adverse impact on safety?"

j. Block 13 – Reliability:

(1) Enter data for estimated corrective maintenance rate. This data may be mean time between failures (MTBF), requisitions, technical feedback reports, or other data showing a corrective maintenance trend. Document source of data (for example, comparable equipment platform, original equipment manufacturer, industrial database).

(2) Block 13a: Under the Impact column, block 13a, enter a "yes" or "no" in answer to the question, "Is the estimated corrective maintenance rate greater than 1 per year?"

k. Block 14 – Cost. Under the Impact column, block 14a, enter a "yes" or "no" in answer to the question, "Is this item's purchase cost greater than $5,000?"

l. Block 15 –Master FSI index transfer: If there is a yes in the Impact column for any block (11a through 14a), then this item is an FSI. Enter "yes" and designate this item for further analysis via FMEA.

m. Block 16 – Serial number. Enter a four-segment serial number as follows:

(1) Segment 1 – see 5.1.1.4.j(1).

(2) Segment 2 – see 5.1.1.4.j(2).

(3) Segment 3 – enter the number "117", indicating the AFSI selection form, followed by a slant (/).

(4) Segment 4 – enter the ESWBS number from block 1.

5.1.3.6 Submission to MCA. Upon completion of Phase 3, the developer shall submit all FFAs, AFSIs, and the FSI index to the MCA for approval with consideration to the following:

a. Functions include outputs, safety features, protective devices, and regulatory requirements.

b. AFSIs are selected for separate analysis based on the subsystem importance or complexity.

c. Functional failures identify unsatisfactory conditions with parameters as appropriate.

d. FSI index delineates all FSIs which will require a failure modes and effects analysis.

5.1.4 Phase 4 – failure modes and effects analysis (FMEA). Upon direction from the MCA, the developer shall perform an FMEA and complete the FMEA data form for each FSI identified and approved on the FSI index. An FMEA shall be required to determine the basic information needed for applying the decision logic. The specific purpose of the FMEA is to determine the dominant failure modes and to determine the effects of each failure mode on the item where it occurs and on higher levels. Analysts should initiate an FMEA at the lowest levels first such that identified failure modes do not have to be repeated at a higher indenture level analysis.

5.1.4.1 Failure modes. Failure modes should be written such that they describe the state of the failure with enough detail to enable further decision making to take place. At the very least, a failure mode should contain a subject of the failure (noun) and a description of what has happened to the item, expressed as either an adjective or a verb. Care should be taken to choose descriptions which accurately reflect the expected failure. For example, a "failed pipe" can be more accurately described as a "corroded pipe" or a "cracked pipe". Either "corrosion" or "cracks" (or both) may result in failure of a piping system; however, each has different causation and requires different maintenance strategies.

A failure mode should give enough information about the problem to enable the analyst to pick the appropriate maintenance strategy during the logic tree analysis. If a simple, subject modifier, failure mode is inadequate to describe the failure, more detail should be added as necessary (for example, does the item fail "open" or "closed"). Additionally, more detail may be required if the failure can happen in a multiple of ways (for example, "valve sticks closed due to corroded seats" vice "valve sticks closed because of salt buildup on valve stem"). Each of these failure modes may be valid for a given valve type, but which failure is going to occur is dependent on what type of system the valve is installed in and what operating and environmental conditions the valve experiences. There may be some systems where both failures are valid. However, the maintenance actions chosen to address one failure may be different from those chosen to address the other. It is up to the analyst to decide the level of detail required to adequately describe the failure mode such that subsequent phases of the process can be completed without having to refine the description and its understanding. Care should be taken to avoid adding complexity that could cause the RCM process to take longer than is necessary.

5.1.4.2 Corrosion related failure modes. Corrosion related failures are the highest cost driver in maintenance across the Department of Defense. When choosing applicable and effective maintenance tasks, special attention should be given to corrosion as a failure mode. There are many different types of corrosion, and each type has a unique associated failure mode, as well as specific preventative tasks. Corrosion prevention directly reduces the cost of correcting corrosion during the life cycle of any given asset.

5.1.4.3 Failure effects. Each of the failure modes documented for the system shall be analyzed to determine its failure effects. Failure effects describe what happens when a failure mode occurs if no other action is taken to otherwise address the failure. The description of the failure effects provides all the information the analyst needs in later phases to determine the consequences of the failure and to aid in the decision making process as to what actions must or should be taken and how good those actions are at reducing the impact of the failure.

In order to ensure the analyst does not fixate on one area of effects (for example, organizational level impact), the effects shall be described starting at the point of the failure mode and continuing up through the levels of subsystem and system to the end effect on the ship or mission. The description of "what happens" (effects) at each level should include, as appropriate:

a. What hazards are posed to operators, other nearby personnel, or the environment?

b. What damage is caused to other equipment as a direct result of the failure or as an indirect result of the loss function?

c. What is the extent of the effect on operations at both the equipment level and at the organization level?

5.1.4.4 Dominant failures. Only those failures deemed to be dominant by the analyst need to be listed as part of the FMEA. Dominant failure modes are those failures which, in the view of the analyst, are important because of the probability of their occurrence or because of the severity of their consequences. By concentrating on dominant failure modes, the FMEA provides a means to filter out unimportant or unlikely failure modes. Only the dominant failure modes listed on the FMEA and marked for transfer shall be subjected to further analysis to determine appropriate maintenance actions. When considering dominant failure modes, consider what is likely to cause equipment failure during its life cycle.

It is allowable to use available tools (for example, failure models, laboratory test data, sensor readings, maintenance records) to assist the analyst with identifying failure causes and associated dominant failure modes for transfer to Phase 5.

5.1.4.5 Documenting the failure modes and effects analysis (DI-SESS-80980/figure A-5). The FMEA data form shall be completed as follows:

a. Block 1 – ESWBS number. Duplicate entry from the FFA or AFSI form, block 1.

b. Block 2 – Nomenclature. Duplicate entry from the FFA or AFSI form, block 2.

c. Block 3 – Ship class. Duplicate entry from the FFA or AFSI form, block 3.

d. Block 4 – Prepared by. Enter the analyst's name and the date.

e. Block 5 – Reviewed by. Enter the first level reviewer's name and the date.

f. Block 6 – Approved by. Reserved for MCA approval signature and the date.

g. Block 7 – Revision. See instructions for the MSSI form in 5.1.1.4.g.

h. Block 8 – Function(s). Duplicate entries from the FFA form, block 10, or the AFSI selection form, block 11.

i. Block 9 – Functional failures. Duplicate entries from the FFA form, block 12, or the AFSI selection form, block 12, as applicable.

j. Block 10 – Dominant failure modes. Enter the dominant failure mode for each functional failure. Number sequentially to correspond to the appropriate functional failure and function; for example, "1.1a", "1.1b", "1.2a". Failure modes should be identified at the level at which the analysis is made. If there are no dominant failure modes, enter "None".

k. Block 11 – Failure effects (local, subsystem, end effect). Enter the details of the effects of each failure mode on the FSI where the failure mode occurs; at local (point of failure), subsystem, and the end effect (ship or mission). If the failure mode has no effect on a particular level, enter "None" in the appropriate column. If the particulars of the effects are such that a safety hazard, environmental threat, or reduction in mission capability results, indicate the following (for example):

(1) Safety hazard to operators.

(2) Safety hazard to personnel in vicinity.

(3) Partial loss of capability to detect and track surface contacts with radar.

(4) Total loss of mobility capability.

(5) Threat to environment.

(6) Violation of regulatory requirement.

(7) If the details of the effects are such that only a redundant item is lost, indicate using the phrase, “loss of redundancy”.

l. Block 12 – Transfer (yes or no). Enter “yes” if the failure mode indicates further analysis should take place. If the failure mode has low severity, or low probability to occur during the life cycle of the equipment, enter “no” and provide rationale for this decision on clearly labeled backup sheets. For failure modes of redundant items, the probability of redundant items failing must be considered. The MCA shall scrutinize this area during the review process. Justification and rationale is not required for a “yes” answer.

m. Block 13 – Serial number. Enter a four-segment serial number as follows:

(1) Segment 1 – see 5.1.1.4.j(1).

(2) Segment 2 – see 5.1.1.4.j(2).

(3) Segment 3 – enter the number “119”, indicating the FMEA form, followed by a slant (/).

(4) Segment 4 – enter the ESWBS number from block 1.

5.1.5 Phase 5 – decision logic tree analysis (LTA) (figure 4). The decision LTA (see figure 4) is a series of yes or no questions that assist the analyst in determining the need for and availability of applicable and effective preventive maintenance tasks. In selecting maintenance tasks and determining task applicability, care should be given to consider the potential for technology solutions, especially sensor technology, with respect to condition monitoring and fault finding. For example, a sensor can be strategically placed that can be used to define a potential failure point. Likewise sensors may also be applicable in finding hidden faults. When there is no appropriate task that is both applicable and effective at preventing the failure, the decision logic tree directs secondary failure management policies (actions) that are appropriate for the risk associated with the failure. The analysis of servicing and lubrication task requirements will be addressed in Phase 6.

5.1.5.1 Existing planned maintenance system (PMS) documentation. Do not review existing PMS documentation before doing the LTA. Use your knowledge about the functions, functional failures, and dominant failure modes to select each task.

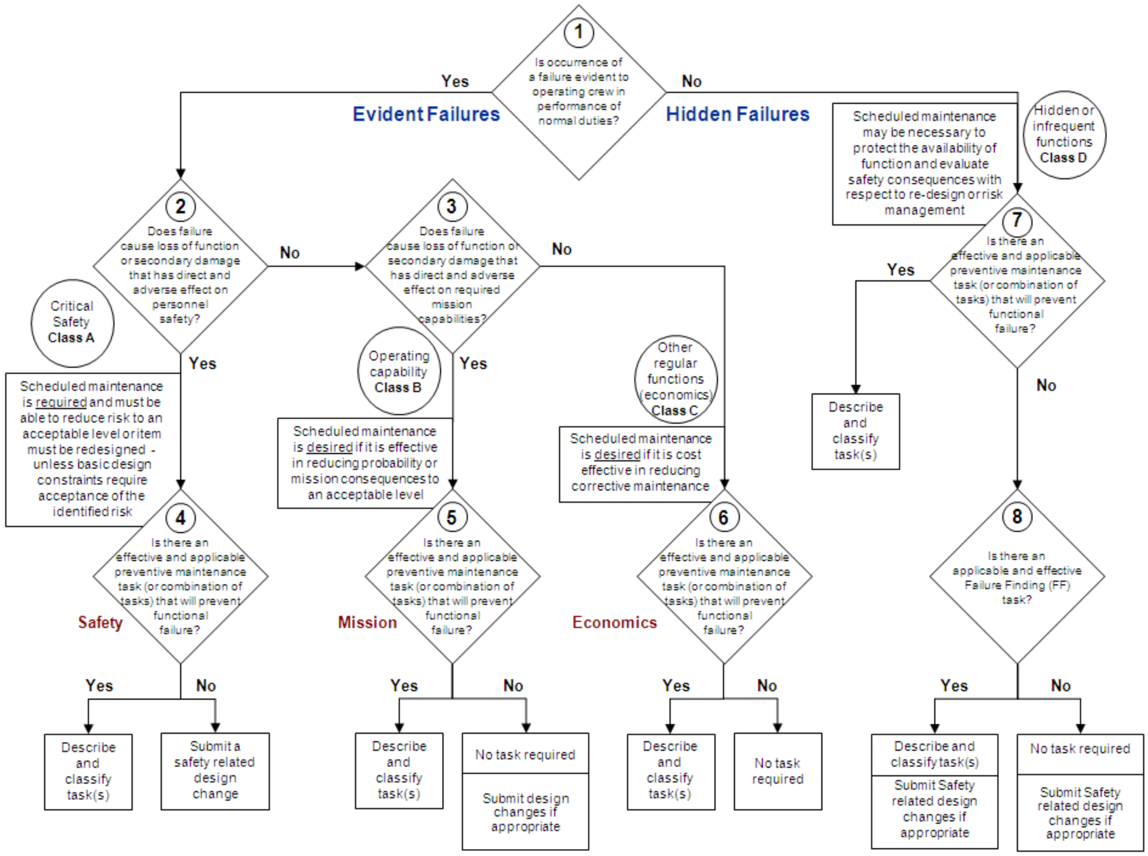

FIGURE 4. RCM decision logic tree.

5.1.5.2 RCM decision logic tree question 1. Is the loss of function (functional failure) evident to the operating crew during the performance of the crew's routine duties? This separates the functional failures into the following two groups:

a. Those functional failures that are evident to the crew during routine duties. The functions in this group are those that are operated either continuously or so often that the crew knows whether a loss of function (functional failure) has occurred.

If question 1 is answered "yes", the analyst shall provide rationale and justification as to how the functional failure is evident. This information shall include the following:

(1) What evidence of failure is observed?

(2) Who observes the evidence?

(3) What part of the observer's routine duties places them in a position to observe the evidence?

b. Those functional failures which are hidden from the crew until the function is actually demanded of this item. Functions in this group are those used intermittently or infrequently so that the crew does not know whether a functional failure has occurred without some special check or test, or those that are not detectable until after another failure. For example, a failed-shut relief valve that cannot be discovered by the crew until over-pressurization damages another item in the system. If an applicable and effective preventive task is available for either failure, it will be used. However, if no task is available that will prevent the hidden failure, a specific task to find the failure may be necessary to tell the crew that restoration of the function is needed and to improve the probability that the function of the item will be available when needed.

If question 1 is answered "no", the analyst must provide rationale and justification as to why the functional failure is hidden (not evident) from the operators during the performance of their routine duties.

5.1.5.3 RCM decision logic tree question 2. Does the failure cause a loss of function or secondary damage that has a direct and adverse effect on personnel safety? This question requires the analyst to evaluate each failure mode and its effects (as documented on the FMEA) to determine if the failure mode has any direct or secondary damage caused by the failure mode or the loss of function caused by the failure mode. Closely investigate if any adverse effect on the safety of operators or other nearby individuals could occur. In the case of safety and protective devices, the analyst is allowed to consider the effects of a secondary failure that would require the device to operate. This question separates the evident failures into the following two groups:

a. Those that directly affect personnel safety. The functional failures in this group are the evident dominant failure modes of any system which impact safety by their occurrence and the evident failures of safety equipment.

If the answer to question 2 is "yes", the analyst shall provide rationale and justification describing the particulars of the threat to life, limb, or health caused as a direct result of the failure.

b. Those that do not affect personnel safety. Functional failures in this group will have an impact on the capability of the organization to perform its mission or support functions.

If the answer to question 2 is "no", rationale and justification are not required.

5.1.5.4 RCM decision logic tree question 3. Does the failure cause a loss of function or secondary damage that has a direct and adverse effect on required mission capabilities? This question requires the analyst to evaluate each failure mode and its effects (as documented on the FMEA) to determine if the failure mode itself, any direct or secondary damage caused by the failure mode, or the loss of function caused by the failure mode, has a direct and adverse effect on the ability of the organization to carry out its assigned military function. This question separates the evident, non-safety-related failures into the following two groups:

a. Those which affect the ability of the organization to perform its military functions.

(1) If the answer to question 3 is "yes", the analyst shall provide rationale and justification describing the mission-critical functions that are degraded by the failure.

b. Those that affect non-mission-related capabilities of the organization.

(1) If the answer to question 3 is "no", rationale and justification are not required.

5.1.5.5 RCM decision logic tree questions 4, 5, 6, and 7. Is there an applicable and effective preventive task (or combination of tasks) that will prevent the functional failure? This question is asked about the dominant failure modes and separates them into the following two groups:

a. Those for which an applicable and effective preventive maintenance task (or tasks) can be specified.

b. Those for which there is no applicable and effective preventive task.

Although this same question is asked in each of the four branches, the answer depends on the consequence of the failure. The task(s) considered should not be limited by the maintenance level at which the task(s) will be done.

5.1.5.5.1 Applicability. A task or group of tasks is applicable if, and only if, the task really does prevent, discover, or reduce the impact of the failure mode in question. Within questions 4, 5, 6, and 7, there are two types of tasks that prevent or reduce failures:

a. Condition-directed (CD) tasks. These tasks are preferred over time-directed tasks because re-work, cleaning, or replacement tasks are not performed unless directed by the hardware condition. CD tasks are periodic tests or inspections to compare the existing conditions or performance of an item with established standards to determine the need for a follow-on renewal, restoration, or repair to prevent the loss of function. For a CD task to be applicable, the occurrence of a specific failure mode must be preceded by a reduction in resistance to failure that is detectable sufficiently in advance of actual failure so that appropriate action can be taken to avoid the actual failure. This states that there must be:

(1) A set of conditions that can be clearly defined that indicate failure is about to occur – a potential failure point (P).

(2) A test or inspection that can be performed often enough to determine the presence of the potential failure prior to actual failure occurrence.

(3) Enough time must exist such that action can be taken to avoid the failure.

b. Time-directed (TD) tasks. These are tasks of periodic restoration or replacement of an item which is performed before the item reaches an age where the risk of failure is much greater than at earlier ages. For a TD task to be applicable, the item must exhibit an increased risk of failure after some age has been reached. A potential failure point does not exist or cannot be measured with accuracy and consistency. These criteria state that for the failure mode of concern:

(1) It must be possible to define an age at which the conditional probability of failure increases.

(2) The probability of failure prior to reaching this age is sufficiently low to limit the risk of premature failure to an acceptable level.

(3) The action proposed by the task must restore the item to a probability of failure more acceptable than that at the predicted age.

5.1.5.5.2 Effectiveness. A task that is applicable to a critical failure (safety, regulatory, or mission) can be effective only if it reduces the risk of failure to an acceptable level. All other preventive tasks can be effective only if they are cost effective; that is, the cost of preventive maintenance is less than the cost of repair plus the cost of lost capability ($C_{PM} < C_R + C_{LC}$). The effectiveness of a task shall be evaluated separately from applicability because the criteria are different.

5.1.5.6 Rationale and justification for questions 4, 5, 6, and 7. Questions 4, 5, 6, and 7 require the analyst to consider both the applicability and effectiveness of any preventive maintenance task chosen. Therefore, the rationale and justification required for yes or no answers to questions 4, 5, 6, or 7 shall address both the applicability and effectiveness of tasks identified.

a. Applicability.

(1) The applicability rationale for CD tasks shall describe:

(a) The potential failure. A measurable point prior to failure.

(b) How the chosen task will discover the potential failure condition.

(c) What actions will be taken if the potential failure point has been reached.

(d) How the follow-on actions will enable avoidance of the actual failure.

(2) The applicability rationale for TD tasks shall describe:

(a) How the reliability of the item is adversely affected by age.

(b) How the risk of premature failure is acceptably low.

(c) How the chosen task restores the system to its design state of reliability.

b. Effectiveness.

(1) The effectiveness rationale for a critical failure shall address how the task reduces the risk of failure to an acceptable level.

(2) The effectiveness rationale for a non-critical failure shall address how the task is cost effective (that is, pays for itself).

5.1.5.7 RCM decision logic tree question 8. Is there an applicable and effective failure finding (FF) task?

This question is asked about hidden functional failures for which no applicable and effective preventive tasks exist. The failure in question here may be safety, regulatory, mission, or economics related. When evaluating FF tasks, the analyst shall evaluate the reliability of the item specifically related to this dominant failure mode, the effects of this dominant failure mode remaining undetected until the function is next needed, and the benefits of performing the task. A task shall not be specified unless it is both applicable and effective. If the dominant failure mode in question is safety related, a safety related design change recommendation shall be identified if no task is available or if the task does not provide sufficient confidence that the safety function will be available when needed. Because of its position in the logic tree and the questions that must be asked and answered before a FF task becomes available, the applicability and effectiveness rules for a FF task are:

a. Applicability: The task must disclose a functional failure that is hidden from the crew during the performance of their routine duties.

b. Effectiveness: The task must provide reasonable assurance that the affected function will be available until the next task accomplishment.

5.1.5.8 Maintenance task periodicity. Each maintenance task shall be assigned a periodicity. The periodicity delineates how frequently the maintenance requirement must be performed. The following tables show example periodicity codes. NAVSEAINST 4790.8 (series) (3-M Manual) contains detailed information on Navy periodicity codes, events, and elements for determining the proper task periodicity. Selecting the longest period between scheduled maintenance tasks to ensure a predicted failure will not occur requires knowledge of component failure and how it occurs as it relates to age and potential failure region. The MCA can provide specific guidance and instruction on the use of periodicity codes, events, and elements, especially the approved list of "R" situational codes.

a. Calendar periodicities:

D	Daily
2D	Every 2 days
3D	Every 3 days
W	Weekly
2W	Every 2 weeks
M	Monthly
2M	Every 2 months

Q	Quarterly
4M	Every 4 months
S	Semi-annually
8M	Every 8 months
9M	Every 9 months
A	Annually
xM	Every x months x = # of months

b. Non-calendar periodicity:

R	Situational requirement
U	Unscheduled or corrective maintenance
AP	Assessment procedure

c. Inactive equipment maintenance:

LU	Lay-up maintenance
PM	Periodic maintenance
SU	Start-up maintenance
OT	Operational test

5.1.5.9 Documenting the RCM decision logic tree analysis (DI-SESS-80984/figure A-6). The RCM LTA data shall be completed as follows:

a. Block 1 – ESWBS number. Duplicate the entry on the FFA or the AFSI selection form, block 1. (Start a new form for each item.)

b. Block 2 – Nomenclature. Duplicate the entry on the FFA or AFSI selection form, block 2.

c. Block 3 – Ship class. Duplicate the entry on the FFA or AFSI selection form, block 3.

d. Block 4 – Prepared by. Enter the analyst's name and the date.

e. Block 5 – Reviewed by. Enter the first level reviewer's name and the date.

f. Block 6 – Approved by. Reserved for MCA approval signature and date.

g. Block 7 – Revision. See instructions for the MSSI form in 5.1.1.4.g.

h. Block 8 – Functional failure and dominant failure mode(s). Enter functional failures and related dominant failure modes receiving a "yes" in block 12 of the FMEA; number each functional failure and dominant failure mode as numbered on the FMEA.

i. Block 9 – Criticality analysis. Enter "Y" or "N" to signify a yes or no answer to each of the first three logic tree questions. Acceptable combinations are as follows:

Question			**Assign criticality class**
1	**2**	**3**	
Y	Y	N/A	A
Y	N	Y	B
Y	N	N	C
N	N/A	N/A	D

j. Block 10 – Criticality class. Enter A, B, C, or D based on the answers in block 9. These letters identify the four main criticality branches of the logic tree as follows:

(1) Class A – personnel safety.

(2) Class B – mission capability.

(3) Class C – other regular functions.

(4) Class D – hidden or infrequent functions.

k. Block 11 – Periodic maintenance (PM) task. Enter "Y" or "N" to signify a yes or no answer to questions 4, 5, 6, or 7 in the logic tree. If the criticality class for this failure is A, the task must be able to reduce the risk to an acceptable level; cost is not a consideration. If no task is available, a safety-related design change recommendation shall be identified in block 13. Justification for a Y or N is required (see 5.1.5.6).

l. Block 12 – FF task. Enter "Y" or "N" to signify a yes or no answer to question 8 in the logic tree. Justification for a Y or N is required (see 5.1.5.6).

m. Block 13 – Redesign recommendation. Enter "yes" if a redesign was identified for this failure, otherwise, enter "no".

n. Block 14 – Task description. Enter a brief description of the applicable and effective task.

o. Block 15 – Periodicity. The periodicity delineates how frequently the maintenance requirement must be performed. Enter the periodicity for accomplishment of tasks in block 14. For periodicities other than calendar based periods, enter a description of the situation which triggers the task.

p. Block 16 – Serial number. Enter a four-segment serial number as follows:

(1) Segment 1 – see 5.1.1.4.j(1).

(2) Segment 2 – see 5.1.1.4.j(2).

(3) Segment 3 – enter the number 120 to indicate the Logic Tree Analysis form, followed by a slant (/).

(4) Segment 4 – enter the ESWBS number from block 1.

5.1.6 Phase 6 – servicing and lubrication analysis. The developer shall perform a servicing and lubrication analysis.

Servicing task: A task that adds or replenishes a consumable item depleted during normal operation (function) and is required in order for the item to perform its required function (for example, a window washing system will not function without sufficient fluid in its reservoir.) Mechanical filter maintenance, replenishment through cleaning or replacement (for example, air, oil, and water) may sometimes be included as a servicing task.

Lubrication task: A task that adds or replenishes a lubricating film (oil or grease) that exists solely to reduce the wear that results from the friction of two surfaces moving in relation to each other.

However, as long as the chosen task satisfies the strict application of the definition for a servicing or lubrication task, it provides benefits which far exceed any associated cost while maximizing the functional availability. Therefore, servicing and lubrication tasks are not processed through the complete logic tree, but instead a more straightforward approach is used to document the need for the servicing or lubrication task. In evaluating these tasks, the following considerations shall be made:

a. Is there evidence from existing data on failed hardware of insufficient or excessive servicing or lubrication? Current periodicities are frequently based only on manufacturers' recommendations and may be excessive. The goal is to determine the tasks that are applicable and effective and determine their correct periodicity.

b. What is the actual periodicity at which this task is performed, and what materials and procedures are used?

c. Can the current method be improved?

d. Can an approved alternative material be used? When practical, common periodicities and materials should be established so that several items can be serviced or lubricated at once, while minimizing the number of different materials required.

e. Are there existing operating procedures or standards that accomplish the requirements of the proposed tasks without the need for creating scheduled maintenance?

5.1.6.1 Documenting the servicing and lubrication analysis (DI-SESS-80985/figure A-7). The servicing and lubrication analysis data shall be completed as follows:

a. Block 1 – ESWBS number. Enter the ESWBS number of the system under analysis, as defined in Phase 1 on the MSSI.

b. Block 2 – Nomenclature. Enter the nomenclature of the system under analysis from block 9 of the MSSI.

c. Block 3 – Ship class. Duplicate the entry from block 3 of the MSSI.

d. Block 4 – Prepared by. Enter the analyst's name and the date.

e. Block 5 – Reviewed by. Enter the first level reviewer's name and the date.

f. Block 6 – Approved by. Reserved for MCA approval signature and date.

g. Block 7 – Revision. See instructions for the MSSI form in 5.1.1.4.g.

h. Block 8 – Item and task description. Enter the nomenclature of each item, and beneath that, the description of each servicing and lubrication task pertinent to that item. When the proposed task is a re-utilization of an existing task from the 3-M system, include MRC SYSCOM control numbers of the existing task.

i. Block 9 – Location. Enter the compartment number(s) where the task is performed.

j. Block 10 – Quantity. Enter the quantity of the items upon which the maintenance task is performed.

k. Block 11 – Previous periodicity. Enter the most recently used periodicity for this task on this or similar items. If this is a new item, enter the manufacturer's recommendation, technical manual, or use engineering judgment.

l. Block 12 – Material specification. Enter the specification and symbols of any material used; for example, oil, grease, or fluid. MIL-HDBK-267 contains lubricant information.

m. Block 13 – Analysis decision. Enter action taken by analysis; NC-no change, OM-omit, CM-change material, CP-change procedure; and the revised periodicity, if appropriate. When making these decisions, reflect on the questions addressed in 5.1.5.

n. Block 14 – Explanation. Enter rationale and justification for the analysis decisions documented in block 13; discuss effectiveness of the task, explain why the change is appropriate (including revised periodicity), outline revised procedures, and specify new materials as appropriate.

o. Block 15 – Serial number. Enter a four-segment serial number as follows:

(1) Segment 1 – see 5.1.1.4.j(1).

(2) Segment 2 – see 5.1.1.4.j(2).

(3) Segment 3 – enter the number "121", indicating the servicing and lubrication analysis form, followed by a slant (/).

(4) Segment 4 – enter the ESWBS number from block 1.

5.1.6.2 Submission to MCA. Upon completion of Phase 6, the developer shall submit the FMEA, RCM LTA, and servicing and lubrication analysis to the MCA for approval with consideration to the following:

a. Dominant failure modes for each functional failure are identified.

b. Applicable and effective tasks are justified.

c. Dominant failure modes with no task required are justified.

d. Servicing and lubrication tasks identify proper procedures and materials.

5.1.7 Phase 7 – inactive equipment maintenance (IEM) task identification. Upon completion of Phase 6, and by the direction of the MCA, the developer shall perform an IEM analysis. The RCM analysis process is focused on preventing equipment failures that occur when the equipment is in use in its normal operating environment. However, equipment is occasionally placed into inactive status during which damage or failure may still occur. It may be beneficial to develop maintenance to prevent this damage if possible and ensure the equipment is fully operational before it is returned to an operational environment. Upon completion of the IEM analysis, and when directed by the MCA, the IEM requirements shall be subjected to procedure validation as specified in 5.1.11.

5.1.7.1 Inactive equipment maintenance (IEM) analysis. Inactive equipment maintenance analysis shall be the basis for determining the maintenance requirements to be performed when equipment is inactivated for periods of prolonged idleness. Tasking may include:

a. Lay-up maintenance (LU) – Prepare the equipment for inactive period.

b. Periodic maintenance (PM) – Prevent equipment deterioration during the inactive period.

c. Start-up maintenance (SU) – Prepare the equipment to become operational.

d. Operational test (OT) – Ensure that the equipment is completely operational at the end of the inactive period.

The analysis shall identify: the maintenance actions required, the source of the required actions, such as existing PMS or technical manuals, and the required procedures available. The IEM analysis will assume that the equipment is in an operable condition when the procedures to inactivate the equipment are implemented and shall be performed using an IEM requirement form. The analysis is a continuation of the requirements investigation process. At the top of the IEM analysis form, enter the equipment item name or nomenclature, the date, and the page number.

5.1.7.2 Documenting the IEM analysis (DI-SESS-80989/figure A-8). The IEM data form shall be completed as follows:

a. Block 1 – ESWBS number. Enter the ESWBS number of the system under analysis, as defined in Phase 1 on the MSSI.

b. Block 2 – Nomenclature. Enter the nomenclature of the system under analysis from block 9 of the MSSI.

c. Block 3 – Ship class. Duplicate the entry from block 3 of the MSSI.

d. Block 4 – Prepared by. Enter the analyst's name and the date.

e. Block 5 – Reviewed by. Enter the first level reviewer's name and the date.

f. Block 6 – Approved by. Reserved for MCA approval signature and date.

g. Block 7 – Revision. See instructions for the MSSI form in 5.1.1.4.g.

h. Block 8 – Degradation. List what degradation will occur if equipment is inactive while ship is (a) operational, and (b) in an industrial environment; for example, regular overhaul (Type Commander or CNO availability) or modernization. Consider separately the equipment's internal workings, external surfaces, attachments, connecting lines, piping, or valves. Under the industrial environment, consider what the effects will be under conditions such as lack of power and heating or cooling problems. Consider the effects if the equipment is exposed to abnormal conditions; for example, having the bulkhead, overhead, and decking removed; or industrial work in progress in the immediate area such as welding, chipping, sandblasting, or painting.

i. Block 9 – Requirements: Considering location and equipment design, state maintenance actions, with alternatives, to protect and prevent degradation of the equipment under the conditions listed.

(1) Block 9a – Protection. List maintenance actions necessary to protect and maintain inactive equipment during a period of prolonged idleness. For example:

(a) Remove equipment and place in a protected area.

(b) Lubricate and cover exposed areas.

(c) Inactivate radar set.

(2) Block 9b – Activation. List maintenance actions necessary to return subsystem or equipment to service following a period of prolonged idleness. Specify what tests are required to ensure the operational readiness of the equipment.

j. Block 10 – Expense. Answer yes or no to the following question: "Considering cost and resources, is the requirement of block 9 worthwhile?" State whether or not the action would satisfy all requirements and give the reason. Justification is required for each requirement listed in block 9 and only the most cost effective requirements should survive the justification. Justification may recommend more than one alternative under different environmental conditions during a shut-down period.

k. Block 11 – Periodicity. Establish the IEM periodicity; lay-up maintenance (LU), periodic maintenance (PM), start-up maintenance (SU), or operational test (OT), for each requirement fully justified in block 10. A maintenance requirement (MR) may be used under more than one IEM periodicity. For periodic maintenance, identify the periodicity of performance required by adding a code to the PM indicator; for example, "PM(W)", "PM(M)". Justify each periodicity decision. If a requirement is to be performed in an industrial environment only, indicate by the notation (I); for example, "LU(I)". This MR shall be entered on the RCM task definition form (Phase 10) with a note to describe the circumstance.

l. Block 12 – Source procedure. Review and list available maintenance procedures that could satisfy the requirements justified in blocks 10 and 11. Maximum use of existing maintenance procedures is desired. Apply existing procedures as written or modify as necessary. Maintenance procedures requiring modifications and maintenance actions which must be developed will be annotated in block 13. Indicate the source of existing procedures. Some of the sources will be technical manuals (TMs), ordnance publications (OPs), or existing MRCs.

m. Block 13 – Editing. This column provides a summary and check-off list of the development work required for IEM. Opposite each MR listed in block 11, indicate what must be done to complete the IEM development with one of the following:

(S)	The MR procedure exists on an MIP and shall be used as written. Enter MRC SYSCOM number.
(M)	The MR procedure exists on an MIP, but the procedure or periodicity shall be modified for IEM. Enter MRC SYSCOM number.
(N)	A complete new procedure shall be developed to satisfy the MR and shall be subjected to procedure validation.

n. Block 14 – Serial number. Enter a four-segment serial number as follows:

(1) Segment 1 – see 5.1.1.4.j(1).

(2) Segment 2 – see 5.1.1.4.j(2).

(3) Segment 3 – enter the number "129", indicating the IEM form, followed by a slant (/).

(4) Segment 4 – enter the ESWBS number from block 1.

5.1.8 Phase 8 – corrective maintenance task identification. Corrective maintenance development is only performed when uniquely identified and funded by the project sponsor via the acquisition documents. Upon completion of Phase 7, and at the approval of the MCA, the developer shall perform a corrective maintenance analysis. The purpose of corrective maintenance task analysis is to identify corrective maintenance and development of approved corrective maintenance tasks. Corrective maintenance consists of those actions required to return systems or equipment from a failed status to an operational condition within predetermined tolerances or limits. Corrective maintenance development is performed to provide a readily available procedure, as an extension to a service technical manual, when a procedure is not provided in the technical manual. These corrective maintenance procedures shall be in the same format as PM procedures, but shall be identified as corrective maintenance. Within Navy PMS, corrective maintenance tasks are listed as unscheduled maintenance requirement cards (UMRCs).

In Phase 4, FMEA, the comprehensive list of dominant failure modes associated with the equipment under analysis is produced. Failures that are of suitable risk (that is, dominant failure modes) are transferred to the logic tree in Phase 5. Consequently, dominant failures transferred to the logic tree are also candidates for corrective maintenance task identification. The Phase 4 dominant failure modes transferred to Phase 5 shall be retrieved for corrective maintenance consideration. Each dominant failure mode shall be evaluated to determine the most appropriate corrective maintenance task: repair task, replace task, or both. Additionally, troubleshoot tasks may be identified during this analysis.

5.1.8.1 Corrective maintenance task analysis process. The following steps shall be taken to identify and classify corrective maintenance:

a. Review FMEA dominant failure modes transferred to Phase 5 (LTA).

b. Identify the corrective maintenance task requirement(s) for dominant failure modes identified in step a. This list shall be approved by the MCA and Program Sponsor prior to developing the corrective maintenance procedures. Consideration for the selection of tasks for UMRC development should be based upon frequency or probability of failure (for example, mean time between failures (MTBF) of the item) and consequence of failure. Corrective maintenance tasks consist of either a repair, replace, and troubleshoot procedures or a combination of these procedures.

c. Identify the maintenance level of repair. The task should be designated for organizational, intermediate, or depot level work using Level of Repair Analysis (LORA).

d. Review task to determine whether sufficient technical documentation exists to write the corrective maintenance procedure, or whether further analysis is required (for example, identify existing corrective maintenance procedures). Procedures that are readily available in Navy technical manuals are not typically selected for UMRC development.

5.1.8.2 Completing the corrective maintenance task list (DI-SESS-81829/figure A-9). The corrective maintenance task list shall be completed as follows:

a. Block 1 – ESWBS number. Enter the ESWBS number from block 8 of the subsystem under analysis, as defined in Phase 1 on the MSSI.

b. Block 2 – Nomenclature. Enter the nomenclature of the subsystem under analysis from block 9 of the MSSI.

c. Block 3 – Ship class. Duplicate the entry from block 3 of the MSSI.

d. Block 4 – Prepared by. Enter the analyst's name and the date.

e. Block 5 – Reviewed by. Enter the first level reviewer's name and the date.

f. Block 6 – Approved by. Reserved for MCA approval signature and date.

g. Block 7 – Revision. See instructions for the MSSI form in 5.1.1.4.g.

h. Block 8 – Dominant failure mode number. The dominant failure mode number shall be taken directly from the LTA block 8 (see 5.1.5.8 h).

i. Block 9 – Dominant failure mode. Enter the verbiage of the dominant failure mode associated with column 8, copied from the LTA form, block 8 (see 5.1.5.8.h).

j. Block 10 – Corrective maintenance task description. The corrective maintenance task description using LORA will typically follow one of three methods. One is to "restore" or "repair" the failed item. Another may be to "replace" the failed item with a new item. Another may be to "troubleshoot" the failed item (especially if it is complex in nature) to identify a failed sub-component for repair or replacing. The dominant failure mode may have one or more of these types of corrective maintenance procedures associated and the three described above are not all-inclusive of what may be required as corrective maintenance. Assign a task "trigger" (for example, "perform when motor will not start" as appropriate).

k. Block 11 – Item mean time between failures (MTBF). If the item MTBF is known, enter it in the list. MTBF is useful to the analyst or MCA to identify which dominant failure modes and consequent corrective maintenance are more likely to occur during the service life of the equipment. MTBF is measured in hours and is typically available from original equipment manufacturer (OEM) documentation. The more frequent failures (that is, dominant failures) are candidates for development of detailed corrective maintenance procedures.

l. Block 12 – Serial number. Enter a four-segment serial number as follows:

(1) Segment 1 – see 5.1.1.4.j(1).

(2) Segment 2 – see 5.1.1.4.j(2).

(3) Segment 3 – enter the number "122", indicating the corrective maintenance form, followed by a slant (/).

(4) Segment 4 – enter the ESWBS number from block 1.

5.1.9 Phase 9 – maintenance requirements index (MRI). The MRI will be a list of maintenance tasks for the subsystem to include scheduled, inactive, and corrective maintenance and the recommended level at which the maintenance should be performed (that is, organizational, intermediate, or depot).

a. Organizational level maintenance: Organizational-level maintenance is the lowest maintenance echelon and consists of all maintenance actions within the capability and resources provided to the organization who routinely oversees equipment operation (for example, ship's force).

b. Intermediate level maintenance: Tasks requiring a higher skill, capability, or capacity than organizational level. Intermediate level maintenance is normally accomplished by centralized repair facility personnel such as the Navy Fleet Maintenance Activity (FMA), submarine refit and support facilities, Regional Maintenance Centers (RMCs), and Battle Group or other Intermediate Maintenance Activities (IMAs).

c. Depot level maintenance: Tasks focused on repair, fabrication, manufacture, assembly, overhaul, modification, refurbishment, rebuilding, test, analysis, design, upgrade, painting, assemblies, subassemblies, software, components, or end items that require specialized facilities, tooling, support equipment, personnel with higher technical skill, or processes beyond the scope of the IMA.

5.1.9.1 Completing the maintenance requirements index(MRI) (DI-SESS-80986/figure A-10). The MRI data form shall be completed as follows:

a. Block 1 – ESWBS number. Enter the ESWBS number of the subsystem under analysis, as defined in Phase 1 on the MSSI.

b. Block 2 – Nomenclature. Enter the nomenclature of the subsystem under analysis from block 9 of the MSSI.

c. Block 3 – Ship class. Duplicate the entry from block 3 of the MSSI.

d. Block 4 – Prepared by. Enter the analyst's name and the date.

e. Block 5 – Reviewed by. Enter the first level reviewer's name and the date.

f. Block 6 – Approved by. Reserved for MCA approval signature and the date.

g. Block 7 – Revision. Enter ORIGINAL, or A, B, or C, sequentially, and the date.

h. Block 8 – Task number. Task numbers are derived from the phase which generated the task as outlined below:

(1) Logic tree analysis (Phase 5): For each task identified in Phase 5, enter a sequential task number in the format LTA-1, LTA-2, etc.

(2) Servicing and lubrication analysis (Phase 6): For each task identified in Phase 6, enter a sequential task number in the format SLA-1, SLA-2, etc.

(3) Inactive equipment maintenance task identification (Phase 7): For each task identified in Phase 7, enter a sequential task number in the format IEM-1, IEM-2, etc.

(4) Corrective maintenance task identification (Phase 8): For each task identified in Phase 8, enter a sequential task number in the format corrective maintenance-1, corrective maintenance-2, etc.

i. Block 9 – Nomenclature. Enter the name or description of the component on which the task is performed.

j. Block 10 – Task description. Enter the task description from the associated development phase (LTA, SLA, IEM, corrective maintenance). This shall be in the form of a sentence and be specific enough to convey the purpose of the task (for example, "Lubricate bevel gear.").

k. Block 11 – RCM task type. For planned maintenance tasks, enter the RCM task type (for example, "CD" for condition-directed, "TD" for time-directed, "FF" for failure finding, or "SL" for servicing or lubrication).

l. Block 12 – Reference. Enter the identification data for the publication that satisfies the task requirement or can be used as a baseline to assist in developing the task procedure. If no publication is available, enter "None".

m. Block 13 – Level of maintenance. Enter the level of maintenance; either "O" for organizational, "I" for intermediate, or "D" for depot level.

n. Block 14 – Periodicity. Enter the initial periodicity for the maintenance task. The initial periodicity for a maintenance task should be based upon similar existing tasks for the equipment, original equipment manufacturer (OEM) guidelines, Naval Ships' Technical Manual (NSTM) guidelines, reliability data, or best engineering judgment, et al. Initial periodicities should be re-evaluated after implementation using the age exploration process described in Appendix B.

o. Block 15 – Serial number. Enter a four-segment serial number as follows:

(1) Segment 1 – see 5.1.1.4.j(1).

(2) Segment 2 – see 5.1.1.4.j(2).

(3) Segment 3 – enter the number "123", indicating the MRI form, followed by a slant (/).

(4) Segment 4 – enter the ESWBS number from block 1.

5.1.10 Phase 10 – maintenance requirement task definition. Upon completion of Phase 9 and at the direction of the MCA, task definition forms shall be prepared for tasks identified in the MRI and specifically designated for further development by the MCA. The task definition process collects sufficient information about the detailed procedures of each task so that a decision can be made as to the appropriate maintenance level (organizational, intermediate, or depot) to perform the tasks and to write the maintenance procedure (see 6.2). Development and verification of Navy maintenance requirement cards (MRCs) shall be in accordance with Appendix C.

5.1.10.1 Preparation guidelines. Task definition forms shall be completed for all tasks identified in the MRI as preventive maintenance. Task definition forms shall be completed for any IEM or corrective maintenance task when specifically designated by the MCA for further development. Tasks identified on the MRI for I or D level accomplishments will be forwarded by the MCA to the cognizant planning authority for incorporation into class maintenance plans. Selecting the echelon (O, I, or D) that will perform each maintenance task is an integral part of the task definition process. If the task frequency is often enough (for example, weekly) and is required to ensure safety or mission capability, it is typically assigned to the organizational level. If the task frequency permits performance by I or D level resources, a choice must be made. This choice will be constrained by the ability of the organization to do the task without external skills, materials, tools, or equipment.

5.1.10.2 Completing the RCM task definition data form (DI-SESS-80988/figure A-11). The task definition data form shall be completed as follows:

a. Tasks covered by existing MRCs. For tasks covered by existing MRCs, a copy of the MRC may be attached to the task definition form in lieu of filling in redundant blocks.

b. Block 1 – ESWBS number. Duplicate the entry from block 1 of the MRI form.

c. Block 2 – Nomenclature. Enter the nomenclature of the item upon which the task is performed from block 2 of the MRI.

d. Block 3 – Ship class. Duplicate entries from block 3 of the MRI.

e. Block 4 – Prepared by. Enter the analyst's name and the date.

f. Block 5 – Reviewed by. Enter the first level reviewer's name and the date. Reserved for engineering review.

g. Block 6 – Approved by. Reserved for MCA approval signature and the date.

h. Block 7 – Revision. Enter ORIGINAL, A, B, or C, sequentially, and the date.

i. Block 8 – Equipment nomenclature. Enter the nomenclature of the item upon which the task is performed from the MRI.

j. Block 9 – Quantity installed. Enter the installed quantity of the item on which this task must be performed.

k. Block 10 – Reference MRC. Enter the reference data from block 12 of the MRI.

l. Block 11 – Maintenance requirement description (task). Enter the task(s) description(s) from the MRI. If applicable, several tasks can be combined into a single maintenance task that incorporates all of the applicable tasks from the MRI (see C.8).

m. Block 12 – Safety precautions. All required safety precautions shall be included in this block. The first entry in this area shall identify general safety requirement documentation by publication number and volume; for example, "Observe standard safety precautions in accordance with Navy Safety Precautions for Forces Afloat, OPNAVINST 5100.19 (series)." or "Navy Safety and Occupational Health (SOH) Program Manual, OPNAVINST 5100.23 (series) for shore activities."

(1) Additional warnings. Additional or more specific warnings shall follow when applicable and shall be listed in the order in which they appear in the procedure area. These warnings will also immediately precede the applicable step.

(2) Additional warnings requiring the use of additional personnel. For those actions which require additional personnel because of safety regulations, the phrase "Do Not Work Alone" shall be added to the applicable safety precaution; for example, "Voltage Dangerous to Life is Present When Interlock Switch is Bypassed. Do Not Work Alone." Appropriate personnel and man-hours must be added when this statement is used.

(3) Capitalization required. The first letter of the first word in each safety precaution shall be capitalized, with all other words in lower case, unless capital letters are required for another reason.

(4) Submarine applications. When Submarine Safety (SUBSAFE) boundaries are to be violated, the statement "Ensure compliance with SUBSAFE Re-entry Control Procedures of COMFLTFORCOMINST 4790.3, Volume V, as applicable." shall appear in this area.

(5) Cleaning solvents. Safety precautions shall be listed when cleaning solvents are involved. The following standard safety precaution is to be used at a minimum whenever cleaning solvents are involved: "Avoid prolonged contact with, or inhalation of, cleaning solvents. Avoid use near open flame and provide adequate ventilation." Approved Navy standard messages are listed in the MRC development software.

n. Block 13 – Periodicity. Enter the periodicity of this task from block 14 of the Maintenance Requirements Index (MRI) form. Enter a two-segment code; for example, "4416 Q-2", "7211 Q-1", or "2331 R-1". The first segment is the ESWBS/MIP series code which will be provided by the applicable MCA. The second segment is the task periodicity. MRCs applicable to more than one MIP series will have each MIP series entered in this block. If more than four MIP series are applicable, reference shall be made to a note. The note shall be numbered and appear in the procedure block to provide the additional information.

o. Block 14 – Rates and man-hours. Identify and enter, by rating and rate, the number of persons required to perform the maintenance requirement and the man-hours for each person. Entries in this area shall be made as follows:

(1) The Navy enlisted classification (NEC) shall be entered if special skills are required.

(2) When both NEC and rates are important to the task, both shall be included; for example, GM2 with the NEC 0876 listed beneath the rate. NECs will not be in parenthesis; multiple NECs will be separated by a slash.

(3) A commissioned officer or warrant officer may be required to be present or available for a specific task indicated in a maintenance procedure. Titles for officers shall be the first entry in the block when applicable; for example, "Damage Control Assistant (DCA)", "Electronic Material Officer (EMO)", "Engineering Officer (Eng. Off.)".

(4) In cases where more than one rating is required, ratings shall be listed after the officers descending by rate within each rating category; for example, "Eng. Off.", "Electrician's Mate First Class (EM1)", and "Machinist's Mate Second Class (MM2)".

(5) When more than one person is required for a particular rate, the appropriate number shall precede the rate; for example, "2 Operations Specialists First Class (2 OS1)", "2 Sonar Technicians Surface First Class (2 STG1)", and "3 Electronics Technicians Second Class (3 ET2)". When two or more persons of the same rate are required and their time requirements are not equal, each person shall be listed separately. When additional personnel are required because of safety regulations, the rate and number of such personnel shall also be included.

(6) In cases where either of two similar ratings can be assigned the work on an MRC, both ratings shall be listed and separated by a slash; for example, "Fire Control Technician First Class (FC1)/Electronics Technician First Class (ET1)", "Gunner's Mate Second Class (GM2)/Gunner's Mate Missiles Second Class (GMM2)."

(7) MRCs shall include the necessary rates to perform the maintenance.

(8) Man-hours (M/H) (converted to hours and tenths of an hour) shall be entered immediately to the right of each rate in the RATES area. When the M/H figure is less than 1 hour, a zero shall appear before the tenths of an hour portion; for example, "0.1" and "0.4." When a commissioned officer or warrant officer is required, no M/H shall be assigned for that person.

(9) The time entered shall indicate the M/H required for each rate as if they were performing their tasks independently. When two or more of the same rating and rate are required and their time requirements are equal, the M/H will be the sum of their time requirements. When two or more persons of the same rating and rate are required and their requirements are not equal, each person must be listed separately. When an MRC does not provide a procedure, but directs the performance of one or more complete MRC(s), the rates and M/H on this "Pointer MRC" will list a single senior rate identified in the MRC Rates and M/H block. The M/H for that person will be a minimal amount, normally 0.1 to cover administrative time to obtain the related MRC. In the IEM area, if there is a large number of related MRCs, the M/H could be increased accordingly.

(10) Equipment warm-up time of 30 minutes or less shall be included in the assigned M/H. Warm-up time in excess of 30 minutes or periods not requiring maintenance technician intervention (for example, charge batteries for 24 hours) shall not be included unless the maintainer is required for constant observance. "Make ready" or "put away" time shall not be included in this area.

(11) When approved by the MCA, a technical procedure from an external document is referred to in the procedure area, the time required to do that portion shall be included in the M/H of the person(s) accomplishing the task of the subject MRC. However, if the referenced procedure is an entire scheduled related MRC, the M/H of that MRC shall not be included. Referencing partial MRC accomplishment is not allowed.

p. Block 15 – Total M/H. Enter the sum of the M/H from the M/H block.

q. Block 16 – Elapsed time. The entry in this area shall indicate the elapsed time, in clock hours and tenths of an hour, from start to finish of the maintenance procedure. The time involved for preparation to accomplish the task and cleanup time upon completion shall not be included. The elapsed time entry does not always duplicate the longest entry in the M/H area. It may be longer when some personnel must wait for other personnel to complete specific actions in order to accomplish certain procedural steps.

r. Block 17 – Tools, parts, materials, test equipment (TPME). Enter and number the required test equipment, materials, parts, tools, and miscellaneous requirements, in that order. Each applicable category shall have a heading. Items within the category shall be numbered and identified by the applicable Standard PMS Materials Identification Guide (SPMIG) number when available. For items without a SPMIG number assigned, refer to 5.1.10.2 r(13). Any item that cannot be substituted by a like item shall state "DO NOT SUBSTITUTE" after the item name. When identifying items in the TPME block, standardization requirements include:

(1) Quantities in excess of one and units of one unit of measure shall be enclosed in parentheses following the nomenclature and complete description of the item. For example, wrench, adjustable 8 inches (2); baking soda (2 pounds).

(2) The symbols ", ', °, and % shall be entered for inch, foot, degree, and percent. Fractions shall be typed with the numerator and denominator separated by a slash; for example, ½, ¼, ⅙.

(3) The term "equivalent" shall not be used with an item listed in this area. Equivalent items, if authorized, shall be specified as a note in the procedure area.

(4) A zero shall be placed before the decimal point when another figure does not precede the decimal. This shall occur even if there is a zero after the decimal point; for example, "wire, non-electrical, 0.041".

(5) A national stock number (NSN) shall not be included in TPME block. NSNs, when authorized, shall be specified as a note in the procedure area.

(6) MRCs for nuclear submarine applications shall use the phrase "approved safety cleaning solvent". For other ship applications, specific cleaners shall be identified. For documentation which will be used for both nuclear submarines and other ships, a double statement will be used; for example, "nuclear submarines: approved safety cleaning solvent; other ships: approved safety cleaning solvent".

(7) When SUBSAFE boundaries are to be violated, ensure compliance with SUBSAFE Re-entry Control Procedures of 0924-062-0010 or COMFLTFORCOMINST 4790.3, Volume V, as applicable. When the scope of certification items are impacted, ensure compliance with DSS-SOC Re-entry Control Procedures of SS800-AG-MAN-010/P-9290 (with the appropriate DSS-SOC Notebook).

(8) Only portable and non-installed equipment required to perform the maintenance procedure shall be listed in the 'tools, parts, materials, test equipment' area. Installed equipment required to support the maintenance procedure shall not be listed. This equipment shall be specified in the appropriate procedural step.

(9) Each entry shall consist of one item only; for example, if an oiler with MIL-PRF-6086 oil is required, the oiler will be listed under the tool heading, and the oil will be listed under the material heading. If more than one oil is required, the procedural step shall specify which oil is required for that step.

(10) In the event that entries in this area must be continued to the second page, the heading information and 'tools, parts, materials, test equipment' shall be printed on the second page.

(11) In the event that entries are to be provided by another activity, the entry will be followed by the phrase, in parentheses, and an explanation provided in the note in the procedure area.

(12) The TPME block is grouped into five categories:

(a) Category 1 – General Purpose Electrical/Electronic Test Equipment (GPETE). The Test, Measurement, Diagnostic Equipment (TMDE) program is controlled by NAVSEA. This program provides comprehensive life-cycle support, encompassing acquisition, outfitting, calibration support, and retirement of GPETE, as well as calibration standards. This includes test equipment that has the potential for use in PMS. GPETE provides a comparison of an unverified equipment or subsystem performance level with the parameters of known and greater accuracy standards (thereby providing precision measurement). Use of GPETE is required to support the maintenance requirements of electronic, electrical, interior communications, weapons, and propulsion prime systems and equipment.

The Sub-Category (SCAT) code is a four- to seven-digit numeric or numeric-alpha code used by NAVSEA to identify a range of measurement requirements by functional category (identified on an associated MRC). Within each currently active SCAT code, test equipment models capable of performing those measurement requirements are assigned to the appropriate SCAT. The TMDE Program is the only authorized agent for the assignment of SCAT codes to system measurement requirements. For prime systems not previously reviewed or test equipment not previously assigned a SCAT code, requests must be forwarded to the TMDE Program Office using an eCalibration and Measurement Requirements Summary (CMRS), DI-QCIC-80278. If the request cannot be matched to approved NAVSEA GPETE and the associated SCAT code assignment, the results will be forwarded back to the requesting Program Office and In-Service Engineering Agent (ISEA) with a SCAT code assignment under Special Purpose Electrical/Electronic Test Equipment (SPETE). It must be understood that a SPETE SCAT assignment requires the requesting Program Office or ISEA to provide all life cycle support including calibration support development to maintain the viability of the instrument until such time as it is replaced or retired.

The NAVSEA TMDE index (TMDE-I) is a guide and reference for the identification of GPETE and SPETE, which has been assigned an SCAT code. The TMDE-I allows cross-reference searches to be accomplished by the following: SCAT code, model number, prime system, ship type, and hull number. The TMDE-I is distributed semi-annually; copies are available upon request from the TMDE help desk email: NAVSEA_GPETE_HELP@navy.mil. The TMDE-I should be used in conjunction with the allowancing document known as the Ship/Shore Portable Electrical/Electronic Test Equipment Requirements List (SPETERL). The TMDE-I does not, under any circumstance, supersede or modify the SPETERL, nor does it authorize the procurement or requisitioning of items not listed in the SPETERL.

The SPETERL is the authoritative allowance document that details onboard prime systems for a specific naval ship or activity. The SPETERL thereby establishes the test equipment configuration to support preventive and corrective maintenance for those subsystems and associated equipment (MRC test equipment requirements must be synchronized with the SPETERL). The listed test equipment (with exception of SPETE) is considered GPETE and supports multiple systems installed onboard ships and shore stations. The listed GPETE (and SPETE) quantities within the SPETERL are used to maintain an onboard inventory that adequately supports measurement requirements. GPETE quantities determined as insufficient or excessive are addressed via the Allowance Change Request (ACR), Naval Supply Systems Command (NAVSUP) Form 1220-2 and submitted through the respective chain of command to the appropriate Fleet Type Commander. Requests for SPETERL reports can be made to the TMDE Program Office via the help desk email: NAVSEA_GPETE_HELP@navy.mil.

(b) Category 2 – Consumables. Consumables constitute a majority of materials required to support maintenance. Category 2 includes a wide range of administrative and housekeeping items which may or may not be consumed in use. Some consumable items (grease, oils, and solvents) are consumed each time the maintenance action is performed whereas others (buckets, funnels, and ladders) are not. Tools are not included in Category 2 even though some tools may fit the general description of a consumable item. Examples of consumable items include ropes, rags, oil, cleaning solvents, brushes, corrosion protection agents, sealants, and protective coatings. By definition, any item appearing on an Allowance Parts List (APL) is considered a repair part (Category 3).

(c) Category 3 – Parts. For purposes of MRC development, repair parts are defined as any item which is an integral part of the equipment. For example, gaskets, mechanical seals, packing material, O-rings, and filters. In general, any item listed in a technical manual or drawing parts list is considered a repair part. An official definition of a repair part is any item appearing on an APL. The medium for identification of PMS repair part requirements to the Navy Supply System is the APL. As commercial off the shelf (COTS) equipment is procured, APLs are not always developed. When no APL is available, replacement parts used during maintenance shall be identified by Commercial and Government Entity (CAGE) code and part number.

(d) Category 4 – Tools. Category 4 includes common hand tools as well as other less commonly used tools; for example, precision measuring devices, dial indicators, micrometer, torque wrenches, and gages. Category 4 covers hand tools of all types except "special tools". Special tools are, by definition, equipment-unique tools that are designed for a particular piece of equipment by the manufacturer. Such tools always have a manufacturer's part number and CAGE code. Special tools will be listed on an APL and are, therefore, classified as repair parts. Equipage items are Category 5 even though some may be used as a tool; for example, jacking gear.

(e) Category 5 – Miscellaneous. Category 5 covers all equipage items as well as any other special materials not otherwise covered under categories 1 through 4. As a general rule, all items which are identified and supported through Allowance Equipage Lists (AELs) will be considered Category 5. Not all Category 5 items are AEL applicable. Typical examples of Category 5 materials are as follows:

1 Test equipment not listed in Category 1.

2 Radiation Detection, Indication, and Computation (RADIAC) equipment or dosimeters.

3 Sound powered phones, binoculars, telescopes, bore sights, and portable equipage items of all types; for example, fans, pumps, or blowers.

4 Boiler feedwater testing equipment. Feedwater chemicals are Category 2.

5 Lube or fuel oil sampling kits, centrifuges, and testing apparatus.

6 All items designated as controlled equipage.

7 Safety harnesses, lanyards, and other safety equipment.

8 Special clothing items including rubber gloves and other items designated to protect users from chemical or toxic agents.

9 Vacuum cleaners of all types.

10 Chain falls, jacking gear devices, and other handling equipment except common hydraulic jacks which are considered Category 4.

11 Special test tapes, diagnostic tapes, or alignment tapes.

12 Special connecting and adapting devices necessary to rig test equipment into prime equipment if such items are not supplied with the test equipment.

13 Special software and support documents including related maintenance MRCs, equipment technical manuals, handbooks, guides, and Naval Ships' Technical Manuals (NSTMs).

a To be classified as related maintenance, the following criteria shall apply:

1) If a maintenance action can be performed before, in conjunction with, or immediately after the task described resulting in a substantial savings in time.

2) If the equipment can be opened once for the accomplishment of more than one MR.

b Related maintenance types. There are three types of related maintenance:

1) Mandatory related maintenance. Must be performed concurrently or in conjunction with another maintenance action because it is an integral part of that procedure.

2) Convenience related maintenance. May be performed concurrently to reflect a savings in man-hours or materials.

3) Conditional related maintenance. All or part of the related MRC is performed when specific conditions are present or not met on the referencing MRC. Conditional related maintenance will appear the same as convenience related maintenance.

(13) Non-SPMIG tools, parts, materials, test equipment. Entries in the 'tools, parts, materials, test equipment' block not covered by the SPMIG, shall be determined and listed as follows:

(a) Electronic and electrical test equipment shall be selected from NAVSEA TMDE-I. Test equipment will be identified by noun name, nomenclature, and SCAT code according to NAVSEA TMDE-I. When SCAT codes are not established, identify by noun name, manufacturer, model number, and AEL number, as applicable.

(b) Materials include lubricants, greases, solvents, cleaning agents and other consumables, such as tape, safety tags, or pencils. Lubricants, greases, solvents, and cleaning agents will be identified by Military, Federal, or Navy specification military symbol and the item name.

(c) Parts include all repair parts such as gaskets or O-rings. Repair parts will be identified by generic name, manufacturer's part number, and the CAGE code. The illustrated parts breakdown, manufacturer's pamphlets, supply catalogs, APLs, and AELs are sources for these nomenclatures.

(d) Special tools such as gage pieces or thrust bars shall be identified by name, manufacturer's part number, and CAGE code.

(e) Common tools shall be identified using the nomenclature format as listed in the alphabetic index of The Afloat Shopping Guide.

(f) Miscellaneous requirements such as MRCs, technical manuals, or forms shall be identified by standard nomenclature or generic name, and company or government identification number.

(g) When the MRC procedure refers to another entire MRC for a step-by-step procedure, that MRC shall be listed.

(h) When published standard operating procedures are available, it is allowable to reference these procedures when full subsystem start-up or shutdown is required prior to or following the maintenance.

(i) When fabrication of a unique tool is required, specifications for fabrications shall be included in the MRC.

s. Block 18 – Procedure. This area shall contain step-by-step instructions to accomplish the maintenance requirement. Illustrations and figures may be added here to enhance understanding of the text. Refer to Appendices C and E and the following for technical writing format considerations for developing Navy PMS procedures:

(1) The language used shall be free of vague and ambiguous terms and shall use the simplest words and phrases that will convey the intended meaning.

(2) Sentence structure shall be short and concise to facilitate understanding and retention of thought. Steps shall be straightforward and simple. Steps with compound clauses shall be converted into sub-steps.

(3) Consistency in choice of words and terminology and organization of material is mandatory.

(4) Steps shall be written to consider the technical qualifications of the rating required to do the task.

(5) Steps shall be written so that no interpretation of how to perform a procedural step is required.

(6) Inspection and measurement steps shall clearly specify limits so that a condition can be easily determined to be acceptable or unacceptable. Define specific recording and reporting requirements for conditions found to allow engineering analysis as related to the validation of the need to perform the prescribed actions. For example, provide illustrations of multiple diesel injector spray patterns depicting a range of good to unsatisfactory, and request identification of the appropriate pattern found during injector testing.

(7) Rewrite steps with extensive punctuation, or break singular steps into multiple steps for clarity.

(8) Ensure that all procedures are safe. Whenever possible, maintenance actions shall be accomplished with equipment in a shutdown condition. Procedural steps directing removal of voltage or pressure shall be explicit as to which switches or valves are intended to be open or closed, when they are within the system boundary, and shall include tag-out action in the same step. When switches or valves are outside the system boundary, reference to the appropriate tag-out guidance (Tag-Out User's Manual or local tag-out instructions) shall be used; for example, "Tag-out [equipment] in accordance with the Tag-out User's Manual or local tag-out instruction." Where components capable of holding a charge are included in the circuitry, a procedural step shall be provided to direct discharge of such components; for example, short high-voltage, high-capacitance components to ground using shorting probe, including the appropriate safety precautions.

(9) When using an abbreviation or acronym, always spell out its meaning the first time it is used on a task definition form.

(10) Names of equipment parts should be identified exactly as imprinted on the equipment (switches, handles, etc.) and the name should be capitalized in the procedural step.

(11) Reference to technical manual procedures should be avoided; however, when approved by MCA, technical manual references may be identified.

t. Block 19 – Ships crew. Enter "Y" or "N" when signifying a yes or no answer to the following question: "Can this task be done by the ship's crew without external skills, materials, tools, or equipment?"

u. Block 20 – Level.

(1) Entry (a): Enter the lowest maintenance echelon at which this task can be done.

(2) Entry (b): Enter the level at which this task should be done. Selecting the echelon (O, I, or D) that will perform each maintenance task is an integral part of the task definition process. This choice will be constrained by the ability of the organization to do the task without external skills, materials, tools, or equipment. Give consideration to organizational workload and class maintenance plan established by the MCA.

v. Block 21 – Location. For ships, enter the compartment number of the space(s) where the item(s) is located. For all other applications, enter nomenclature to uniquely identify item(s) location.

w. Block 22 – Serial number. Enter a four-segment serial number as follows:

(1) Segment 1 – Enter the developing organization abbreviation followed by a slant (/).

(2) Segment 2 – For developers, enter the development authorization number followed by a slant (/); for other development activities, assign a development number followed by a slant (/).

(3) Segment 3 – Enter the number 124 indicating the task definition form followed by a slant (/).

(4) Segment 4 – Enter the ESWBS number from block 1.

5.1.10.3 Engineering reviews. The developing activity shall conduct appropriate engineering reviews of the technical information to ensure that it is safe, complete, logical, technically accurate, and comprehensible. Based on these reviews, the developing activity shall certify prior to validation that the technical information permits efficient performance of the intended equipment support functions and that the technical information is ready for validation. All errors noted during the engineering review shall be corrected prior to validation. The developing activity shall maintain engineering review records and shall indicate certification by signing block 5 of the task definition form.

5.1.11 Phase 11 – maintenance procedure validation. When directed by the MCA, each maintenance task procedure that evolves from the RCM process shall be subjected to a procedure validation (sometimes referred to as a “shipcheck”). All tasks including corrective procedures shall be validated as much as possible without doing a major breakdown of the equipment. Validated maintenance tasks are a certified product that is verified safe, technically sound, and capable of being performed by the rate identified, without any interpretation required. Procedure validation shall be performed by taking the written procedure to the actual equipment as installed onboard the ship or shore facility and, in the presence of the maintenance technician(s), completely validate all steps in the procedure as well as the supporting information (see 6.2). The procedure validation shall verify the following elements:

a. The procedure can be safely and effectively performed as written in the task definition, including the tag-out requirements, safety warnings, cautions, and notes.

b. The procedure makes sense from an engineering standpoint, is commensurate with resources available to the user, and that the equipment on which the maintenance is performed is accessible.

c. Whether or not Hazardous Material (HAZMAT) is required for the procedure and, if so, that proper protective procedures and disposal directions are provided.

d. The correct number of ratings and pay grades of maintenance personnel are identified.

e. The correct tools, parts, consumables, and miscellaneous items are specified.

f. The correct elapsed time to perform the procedure is specified.

g. Actions that do not support accomplishment of the MR are eliminated.

h. The system, equipment, or components are found easily and if additional information (compartment, level, frame #, component ID, near, upstream downstream of ___) in the procedure is required to make the maintenance requirement more efficient.

i. The system, equipment, or components are accessible without requiring external activity assistance to remove interference.

j. If pictures or hand drawn diagrams are required (interference, item locations, etc.) to assist with the final maintenance development.

k. Any interference to determine if removal steps in the procedure would make the maintenance requirement more efficient.

l. The system, equipment, or component identifying marks, designations, labels, etc., used in the MRC match the actual system, equipment, or component.

m. The specified plant conditions, ship parameters, etc., are appropriate for performance of the MRC.

n. All special tools, rigging, or external activities required are identified on the MRC.

o. The cleanliness requirements are appropriate as identified.

p. The procedural steps are standalone, factual, concise, easily interpreted, and flow in a logical order.

q. The figures, drawings, illustrations, and tables match the equipment or components.

5.1.11.1 Validation requirements. Validation is a developing activity quality assurance responsibility that shall be accomplished for all maintenance tasks, changes, and revisions thereto. Validation shall provide a measure of the overall quality of the maintenance tasks. Validation shall be performed by individuals who are of approximately the same education, experience, and skill level as the actual target audience for the maintenance tasks. The MCA or In-Service Engineer Agent (ISEA) reserves the right to witness validation. The preparing activity shall notify the MCA or ISEA of the validation schedule prior to commencement. A maintenance task shall not be validated until the following conditions have been fulfilled:

a. Developing activity's engineering technical review has been completed.

b. Information reflects configuration of the systems and equipment.

c. Procedural instructions are readily understandable by the intended user and adequate to perform all intended functions.

d. Adequacy of data is checked to ensure that it supports the approved maintenance strategy.

e. Hardware of the proper configuration is available for the validation effort. An operational environment shall be used, if possible, or simulated, if practicable.

5.1.11.2 Validation performance. Operating and maintenance procedures including checkout, alignment, removal and replacement instructions, and associated checklists shall be validated against the system and equipment by actual demonstration. Malfunctions shall not be introduced into the system or equipment for the purpose of validation unless specifically required for certification of procedural tasks or system tests. Destructive malfunctions shall not be introduced into the system or equipment for any purpose.

5.1.11.3 Documenting the procedure validation (DI-SESS-80987/figure A-12). The purpose of the procedure validation is to collect data, at the location of the equipment, in order to improve or amend the maintenance task definition. This data will be used by developers to adjust the task definition and be approved by the MCA prior to authoring, publishing, and delivery of maintenance procedures to the end user. Data required for procedure validation may be modified by the MCA as required, but represents the information that is typically important to validate. A procedure validation should be prepared for each new maintenance procedure. When more than one page is required, the procedure validation may include continuation pages. Procedure validation data shall be completed as follows:

a. Block 1 – Local control number. Enter the local control number as designated by the MCA.

b. Block 2 – Nomenclature. Enter the nomenclature of the subsystem, subsystem equipment group, or equipment, at the lowest hierarchical level that all maintenance on the task definition form is applicable (for example, if maintenance tasks require interface with two pieces of equipment, the next higher indentured level will be indicated as nomenclature).

c. Block 3 – Ship class. Enter the class of ship.

d. Block 4 – MRC serial. Enter the MRC serial number or proposed number for reference purposes.

e. Block 5 – Ship/Hull/Facility. Enter the ship hull number or facility nomenclature.

f. Block 6 – Workcenter. Enter the workcenter responsible for the maintenance, if available.

g. Block 7 – Periodicity. This block contains task periodicity.

h. Block 8 – Maintenance requirement description. Enter a brief task description of the maintenance requirement. Utilize task procedure indicated on the Phase 10 task definition form that has undergone an engineering technical review and certified that technical information is correct, will not damage equipment, and is safe to perform.

i. Block 9 – Tag-out required? Enter whether a tag-out is required to safely perform the procedure.

j. Block 10 – HAZMAT required? Enter whether HAZMAT is required to perform the procedure.

k. Block 11 – Procedure modification? Indicate whether the procedure, as currently written, will require modification. This is a yes/no statement.

l. Block 12 – Safety concerns. Refer to block 12 of the RCM task definition form from Phase 10. Enter any additional safety concerns realized during the procedure validation.

m. Block 13 – Expected elapsed time. Enter the expected elapsed time to perform the procedure from block 14 of the maintenance requirement task definition.

n. Block 14 – Actual elapsed time. Enter the elapsed time to perform the procedure as determined by the shipcheck. If it is the same as the estimate, enter "same".

o. Block 15 – Personnel validation. Indicate whether the ratings and pay grades required to perform the procedure are valid. This is a yes/no statement.

p. Block 16 – Comments/Narrative. Enter recommended changes, in freeform text, to the procedures, personnel, tag-out, HAZMAT, etc. This block shall be used to address deficiencies identified in the preceding yes/no questions.

q. Block 17 – Date & location. Enter the date the validation was performed and the shipboard location of the equipment, as applicable.

r. Block 18 – Evaluator. Enter contact information for the person performing the validation to include: name, title, activity, phone number, and email address, as applicable.

5.1.12 Phase 12 – maintenance index page (MIP) and maintenance requirement card (MRC) development and preparation. MIP and MRC development and preparation shall be in accordance with Appendix C. The MCA will direct the contractor to develop MIPs and MRCs for specifically designated tasks identified in Phase 9. The MCA will forward Intermediate and Depot Level tasks to the appropriate organization for development of CMP tasks. The format and content of MIPs and MRCs shall be in accordance with DI-SESS-80992 (MIP) and DI-SESS-80991 (MRC), and Appendix C of this standard. The CMP shall be developed in accordance with DI-SESS-81823.

6. NOTES

6.1 Intended use. The maintenance procedures and associated artifacts produced in accordance with this standard are intended for use in the Navy 3-M program. They apply to inspecting, cleaning, lubricating, replacing, adjusting, calibrating, functional testing, and system testing of equipment and systems located on ships, submarines, and shore stations. When identified as a unique deliverable, tasks developed may also include corrective maintenance procedures for aligning, repairing, and troubleshooting failed equipment.

6.2 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number, and date of this standard.

b. Security classification of material to be used in development (see 4.2).

c. Identification of Maintenance Coordinating Activity (see 4.4).

d. Each RCM analysis phase to be developed and delivered (see 5.1).

e. Identification of subsystem or equipment for which the maintenance requirements are to be developed (see 5.1.1).

f. Schedules and identification of applicable tasks described in this standard; these include applicable development phases, preparation of the verification draft, documentation validation, and shipment of deliverable items (see 5.1.10 and 5.1.11). Corrective maintenance analysis and MRC development requires a separate line item to invoke DI-SESS-81829. When not uniquely specified in the acquisition document, corrective maintenance analysis should not be performed.

g. Composition and layout requirements for MRCs (see C.22.1 and C.22.2).

6.3 Associated Data Item Descriptions (DIDs). This standard has been assigned an Acquisition Management Systems Control (AMSC) number authorizing it as the source document for the following DIDs. When it is necessary to obtain the data, the applicable DIDs must be listed on the Contract Data Requirements List (DD Form 1423).

DID Number	DID Title
DI-SESS-80979	Reliability-Centered Maintenance (RCM) Master System and Subsystem Index (MSSI)
DI-SESS-80980	Reliability Centered Maintenance (RCM) Failure Modes and Effects Analysis (FMEA) Report
DI-SESS-80981	Reliability Centered Maintenance (RCM) Functional Failure Analysis (FFA) Report
DI-SESS-80982	Reliability-Centered Maintenance (RCM) Functionally Significant Item (FSI) Index

DI-SESS-80983	Reliability Centered Maintenance (RCM) Additional Functionally Significant Item (AFSI) Selection Report
DI-SESS-80984	Reliability Centered Maintenance (RCM) Logic Tree Analysis (LTA) with Supporting Rationale and Justification Report
DI-SESS-80985	Reliability Centered Maintenance (RCM) Servicing and Lubrication Analysis (SLA) Report
DI-SESS-80986	Reliability Centered Maintenance (RCM) Maintenance Requirement Index (MRI)
DI-SESS-80987	Reliability Centered Maintenance (RCM) Procedure Validation Report
DI-SESS-80988	Reliability Centered Maintenance (RCM) Task Definition Report
DI-SESS-80989	Reliability Centered Maintenance (RCM) Inactive Equipment Maintenance (IEM) Requirement Analysis Report
DI-SESS-80991	Planned Maintenance System (PMS) Maintenance Requirement Card (MRC)
DI-SESS-80992	Planned Maintenance System (PMS) Maintenance Index Page (MIP)
DI-SESS-80994	Reliability-Centered Maintenance (RCM) Functional Block Diagram (FBD)
DI-SESS-81823	Reliability-Centered Maintenance (RCM) Class Maintenance Plan (CMP)
DI-SESS-81829	Reliability Centered Maintenance (RCM) Corrective Maintenance (CM) Development Report

The above DIDs were current as of the date of this standard. The ASSIST database should be researched at http://quicksearch.dla mil to ensure that only current and approved DIDs are cited on the DD Form 1423.

6.4 Supersession data. This standard supersedes MIL-P-24534. Phase 12 requirements for the development of MRCs and MIPs are specified in Appendix C of this standard. This standard does not negate, or require review and update, of any RCM analysis previously performed in accordance with MIL-P-24534.

6.5 NAVSEA. Depending on the context, the word NAVSEA in this standard pertains to NAVSEA only, and signifies the current NAVSEA practice. For other organizations, it is an example to be used as guidance.

6.6 Subject term (key word) listing.

Active function

Condition-directed (CD) task

Corrective maintenance

Decision logic tree analysis (LTA)

Failure effects

Failure mode

Failure modes and effects analysis (FMEA)

Functional failure

Functionally significant item (FSI)

Hidden function

Master system and subsystem index (MSSI)

Passive function

Periodicity

Potential failure

Preventative maintenance

Redundancy

Time-directed (TD) task

6.7 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extent of the changes.

RCM ANALYSIS DATA COLLECTION FORMS

A.1 SCOPE

A.1.1 Scope. This Appendix consists of sample forms to indicate the data to be provided as called out in the DIDs for different phases of RCM covered by this standard. The data itself is to be provided electronically. This Appendix is not a mandatory part of the standard. The information contained herein is intended for guidance only.

<table>
<tr><td>1. ESWBS GROUP NUMBER</td><td colspan="3">2. GROUP NOMENCLATURE</td><td>3. SHIP CLASS</td><td>SH OF</td></tr>
<tr><td colspan="2">4. PREPARED BY
DATE</td><td>5. REVIEWED BY
DATE</td><td>6. APPROVED BY
DATE</td><td colspan="2">7. REVISION
DATE</td></tr>
<tr><td>8. ESWBS SUBGROUP/
SUBSYSTEM NUMBER</td><td colspan="5">9. SUBGROUP/SYSTEM/SUBSYSTEM NOMENCLATURE</td></tr>
<tr><td></td><td colspan="3"></td><td colspan="2">10. SERIAL NUMBER</td></tr>
</table>

MASTER SYSTEMS AND SUBSYSTEMS INDEX

FIGURE A-1. Master systems and subsystems index (MSSI).

1. ESWBS NUMBER	2. NOMENCLATURE		3. SHIP CLASS	SH OF
4. PREPARED BY DATE	5. REV EWED BY DATE	6. APPROVED BY DATE	7. REVISION DATE	
8. SOURCES OF NFORMATION				
9. DESCR PTION (Add additional sheet, if necessary)				
10. FUNCTIONS AND OUT NTERFACES				
11. SYSTEM IN NTERFACES				
12. FUNCTIONAL FAILURES			13. SERIAL NUMBER	

FUNCTIONAL FAILURE ANALYSIS

FIGURE A-2. Functional failure analysis (FFA).

<table>
<tr><td colspan="2">1. ESWBS NUMBER</td><td colspan="3">2. NOMENCLATURE FSI CANDIDATE</td><td>3. SHIP CLASS</td><td>SH OF</td></tr>
<tr><td colspan="2">4. PREPARED BY
DATE</td><td>5. REVIEWED BY
DATE</td><td colspan="2">6. APPROVED BY
DATE</td><td colspan="2">7. REVISION
DATE</td></tr>
<tr><td colspan="5">8. DESCR PTION</td><td colspan="2">9. LOCATION

10. QTY</td></tr>
<tr><td colspan="6">11. FUNCTIONS

ARE ANY OF THESE FUNCTIONS NECESSARY FOR SAFETY, MOBILITY, OR MISSION?</td><td>11A. MPACT? (Y/N)</td></tr>
<tr><td colspan="6">12. FUNCTIONAL FA LURES

DO ANY OF THESE FA LURES HAVE A D RECT ADVERSE IMPACT ON SAFETY?</td><td>12A. MPACT? (Y/N)</td></tr>
<tr><td colspan="6">13. RELIABILITY

IS THE ESTIMATED CORRECTIVE MA NTENANCE RATE GREATER THAN 1 PER YEAR?</td><td>13A. MPACT? (Y/N)</td></tr>
<tr><td colspan="6">14. COST

IS THIS ITEM'S PURCHASE COST GREATER THAN $5000?</td><td>14A. MPACT? (Y/N)</td></tr>
<tr><td colspan="4">15. MASTER FSI NDEX TRANSFER? (Y/N)</td><td colspan="3">16. SERIAL NUMBER</td></tr>
</table>

ADDITIONAL FUNCTIONALLY SIGNIFICANT ITEMS SELECTION

FIGURE A-3. Additional functionally significant items (AFSI).

1. ESWBS NUMBER	2. SUBSYSTEM NOMENCLATURE		3. SHIP CLASS	SH OF
4. PREPARED BY DATE	5. REVIEWED BY DATE	6. APPROVED BY DATE	7. REVISION DATE	
8. ESWBS NUMBER	9. NOMENCLATURE		10. LOCATION	
		11. SERIAL NUMBER		

FUNCTIONALLY SIGNIFICANT ITEMS INDEX

FIGURE A-4. Functionally significant items index (FSI index).

<table>
<tr><td colspan="2">1. ESWBS NUMBER</td><td colspan="3">2. NOMENCLATURE</td><td>3. SHIP CLASS</td><td>SH OF</td></tr>
<tr><td colspan="2">4. PREPARED BY
DATE:</td><td colspan="2">5. REVIEWED BY
DATE:</td><td>6. APPROVED BY
DATE:</td><td colspan="2">7. REVISION
DATE:</td></tr>
<tr><td>8. FUNCTION(S)</td><td>9. FUNCTIONAL FAILURES</td><td>10. DOMINANT FAILURE MODES</td><td colspan="3">11. FAILURE EFFECTS: a. LOCAL
b. SUBSYSTEM
c. END EFFECT</td><td>12. TRANSFER
Y / N</td></tr>
<tr><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td colspan="3"></td><td></td></tr>
<tr><td colspan="4">13. SERIAL NUMBER</td></tr>
</table>

FAILURE MODES AND EFFECTS ANALYSIS

FIGURE A-5. Failure modes and effects analysis (FMEA).

1. ESWBS NUMBER	2. NOMENCLATURE	3. SHIP CLASS	SH OF
4. PREPARED BY DATE:	5. REVIEWED BY DATE:	6. APPROVED BY DATE:	7. REVISION DATE:

8. FUNCTIONAL FAILURE/ DOMINANT FAILURE MODE	9. CRITICALITY ANALYSIS (1)	(2)	(3)	10. CRITICALITY CLASS A B C D	11. PM TASK? (Y/N) (4, 5, 6, or 7)	12. FAILURE FINDING TASK? (8)	13. REDESIGN? (Y/N)	14. TASK DESCRIPTIONS	15. PERIO-DICITY
							16. SERIAL NUMBER		

LOGIC TREE ANALYSIS

FIGURE A-6. Logic tree analysis (LTA).

1. ESWBS NUMBER	2. NOMENCLATURE					3. SHIP CLASS	SH OF
4. PREPARED BY DATE	5. REVIEWED BY DATE		6. APPROVED BY DATE			7. REVISION DATE	
8. ITEM AND TASK DESCRIPTION	9. LOCATION	10. QUANTITY	11. PERIODICITY	12. MATERIAL SPECIFICATION	13. ANALYSIS DECISION	14. EXPLANATION	
					15. SERIAL NUMBER		

SERVICING AND LUBRICATION ANALYSIS

FIGURE A-7. Servicing and lubrication analysis (SLA).

1. ESWBS NUMBER	2. NOMENCLATURE	3. SHIP CLASS	SH OF

4. PREPARED BY DATE:	5. REVIEWED BY DATE:	6. APPROVED BY DATE:	7. REVISION DATE:

8. DEGRADATION: a. operat onal b. ndustrial environment	9. REQUIREMENTS		10. EXPENSE		11.PERIODICITY (LU, PM, SU, OT)		12. SOURCE PROCEDURE (TM, OP, MRC, ETC.)	13. EDITING (S) (M) (N)
	9a. Protection	9a. Activat on	Y / N	Justify	Code	Justify		
					14. SERIAL NUMBER			

INACTIVE EQUIPMENT MAINTENANCE (IEM)

FIGURE A-8. Inactive equipment maintenance (IEM).

1. ESWBS GROUP NUMBE R	2. GROUP NOMENCLATURE	3. SHIP CLASS	SH OF
4. PREPARED BY DATE	5. REVIEWED BY DATE	6. APPROVED BY DATE	7. REVISION DATE

8. FAILURE MODE NUMBER	9. FAILURE MODE	10. CM TASK DESCRIPTION	11. ITEM MTBF
		12. SERIAL NUMBER	

CORRECTIVE MAINTENANCE TASK LIST

FIGURE A-9. Corrective maintenance task list.

1. ESWBS NUMBER	2. NOMENCLATURE	3. SH P CLASS	SH OF

4. PREPARED BY DATE:	5. REV EWED BY DATE:	6. APPROVED BY DATE:	7. REVISION DATE:

8. TASK NUMBER	9. NOMENCLATURE	10. TASK DESCRIPTION	11. RCM TASK TYPE	12. REFERENCE / PUBLICATION	13. LEVEL OF MAINTENANCE	14. PERIODICITY
			15. SERIAL NUMBER			

MAINTENANCE REQUIREMENTS INDEX

FIGURE A-10. Maintenance requirements index (MRI).

1. SYS/SUBSYS ESWBS NUMBER
2. SYSTEM/SUBSYSTEM NOMENCLATURE
3. SHIP CLASS
SH OF

4. PREPARED BY
DATE
5. REVIEWED BY
DATE
6. APPROVED BY
DATE
7. REVISION
DATE

8. EQUIPMENT NOMENCLATURE
9. QTY. NSTALLED
10. REFERENCE MRC

11. MA NTENANCE REQU REMENT DESCR PTION (TASK)
13. PERIODICITY
14. RATES
M/H
12. SAFETY PRECAUTIONS
15. TOTAL M/H
16. ELAPSED TIME

17. TOOLS, PARTS, MATERIALS, TEST EQUIPMENT

18. PROCEDURE

19. SH P'S CREW? (Y/N)
20. LEVEL: (a)
(b)

21. LOCATION
22. SERIAL NUMBER

TASK DEFINITION

FIGURE A-11. RCM task definition.

1. LOCAL CONTROL NUMBER	2. NOMENCLATURE		3. SHIP CLASS	SH OF
4. MRC SERIAL	5. SHIP/ HULL / FAC LITY	6. WORKCENTER	7. PERIODICITY	

8. MA NTENANCE REQUIREMENT DESCRIPTION	9. TAGOUT REQUIRED? Y / N
	10. HAZMAT REQUIRED? Y / N
	11. PROCEDURE MOD? Y / N
12. SAFETY CONCERNS	13. EXPECTED ELAPSED T ME
	14. ACTUAL ELAPSED TIME
	15. PERSONNEL VALID? Y / N

16. COMMENTS / NARRATIVE

17. DATE & LOCATION	18. EVALUATOR

PROCEDURE VALIDATION

FIGURE A-12. Procedure validation.

AGE EXPLORATION

B.1 SCOPE

B.1.1 Scope. This Appendix provides a short description of age exploration (AE), which is part of back-fit RCM, as it relates to time-directed (TD), condition-directed (CD), and failure-finding (FF) tasks. This Appendix does not provide a detailed treatment of AE, which is outside the scope of this standard. This Appendix is not a mandatory part of the standard. The information contained herein is intended for guidance only.

B.2 INTRODUCTION

AE is an important aspect of the RCM program because determining the optimum interval for performing a preventive maintenance task can be difficult. The RCM analysis is a very systematic process to determine what preventive maintenance tasks should be done, but the process does not tell us when these tasks should be performed.

B.3 AGE-RELIABILITY RELATIONSHIP

AE requires understanding of how a given material changes over time and how that change results in a failure mode. If we know the age-reliability relationship for a specific failure mode, it enables us to seek a TD task needed to prevent the failure mechanism related to known aging. Knowing the age-reliability relationship also provides the necessary statistical information to determine the TD task interval.

B.4 RELIABILITY DATA ANALYSIS

Reliability data gathered from 3-M and other sources (for example, meter readings, CASREPS) can be used to estimate MTBF and mean time to failure (MTTF) for components. Consequently, these MTBF and MTTF values can be input into system modeling software to estimate the most efficient maintenance periodicities, as well as predict when equipment failures may occur. Models can be updated with as-found equipment condition to refine prediction capabilities.

B.5 TD TASKS

However, in reality, the precise age-reliability relationship is usually not known. Therefore, one has to use one's operating experience to estimate the initial task interval for performing a TD task. One is likely to be conservative at this stage and pick too short an interval. AE is a process to correct this expensive conservatism.

B.6 CD AND FF TASKS

The applicability of a CD task depends on the ability to measure reduced failure resistance. Its effectiveness depends on the inspection interval. The same is true for FF tasks. Thus, CD and FF tasks also require determination of intervals for inspection and data acquisition. In absence of statistical information to determine such intervals, one is again compelled to estimate, starting out with a conservative periodicity. Here also, one can use AE to correct this expensive conservatism. For a CD task, however, one not only needs to specify a task interval, but also a parameter value indicating a potential failure condition.

B.7 REFINING THE ESTIMATE

After initially estimating a task interval, one can use AE to refine this estimate in a systematic manner to improve the accuracy of the interval. AE is an empirical technique that involves changing the initial task interval by a percentage (for example, 10 percent), provided a complete and thorough inspection does not indicate any signs of aging or wear and tear. This process is repeated until an inspection indicates signs of aging or wear and tear. Once this happens, the AE process is stopped, and the task interval is reduced by the same fixed percentage (for example, 10 percent) to define the final task interval.

MAINTENANCE INDEX PAGE (MIP) AND MAINTENANCE REQUIREMENT CARD (MRC) DEVELOPMENT GUIDE

C.1 SCOPE

C.1.1 Scope. This appendix describes the process for development and verification of the Maintenance Requirement Card (MRC). This Appendix is a mandatory part of the standard. The information contained herein is intended for compliance.

C.1.2 Use of technology. The maintenance developer may use the current editor program used for creating Navy PMS documentation to facilitate the development of MRCs. The Navy PMS editor is designed to support standards and current guidelines during the construction of MRCs. The editor program may be obtained by contacting the MCA.

C.2 APPLICABLE DOCUMENTS

C.2.1 General. The documents listed in this section are specified in this appendix. This section does not include documents cited in other sections of this standard or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in this appendix, whether or not they are listed.

C.2.2 Government documents.

C.2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified therein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-38784	-	Manuals, Technical: General Style and Format Requirements

(Copies of these documents are available online at http://quicksearch.dla mil.)

C.2.2.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

NAVAL SEA SYSTEMS COMMAND (NAVSEA) PUBLICATIONS

NAVSEA OP1700	-	Standard Fire Control Symbols for Missile Related Quantities
S9086-KC-STM-010	-	Naval Ships' Technical Manual, Chapter 300, Electric Plant-General
S9086-WK-STM-020	-	Naval Ships' Technical Manual, Chapter 670, Volume 2, Afloat Hazardous Material Control and Management Guidelines; The Hazardous Materials Users Guide (HMUG)

(Copies of these documents are available online at https://nll.ahf.nmci navy mil, may be requested by phone at 215-697-2626, or may be requested by email at nllhelpdesk@navy mil. These publications can be located by searching the Navy Publications Index for the TMIN without the suffix.)

U.S. GOVERNMENT PRINTING OFFICE

United States Government Printing Office Style Manual

(Copies of this document are available online at www.gpo.gov.)

C.2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

ASME INTERNATIONAL

ASME Y14.38 - Abbreviations and Acronyms for Use on Drawings and Related Documents

ASME Y14.44 - Reference Designations for Electrical and Electronics Parts and Equipment

(Copies of these documents are available online at www.asme.org.)

ASTM INTERNATIONAL

ASTM F856 - Standard Practice for Mechanical Symbols, Shipboard—Heating, Ventilation, and Air Conditioning (HVAC)

(Copies of this document are available online at www.astm.org.)

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC. (IEEE)

IEEE 91 - IEEE Standard Graphic Symbols for Logic Functions

IEEE 315 - IEEE Graphic Symbols for Electrical and Electronics Diagrams (Including Reference Designation Letters)

(Copies of these documents are available online at www.ieee.org.)

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO-81714-1 - Design of graphical symbols for use in the technical documentation of products -- Part 1: Basic rules

(Copies of this document are available online at www.iso.org.)

C.3 STYLE OF TEXT

Text shall be prepared in accordance with the styles specified in the following paragraphs.

C.3.1 Wording of text. The procedural steps shall be factual, clear, concise, and not susceptible to misinterpretation (see Appendix E). This includes without limitation, the following requirements:

a. Omit theory.

b. Where possible, avoid phraseology requiring specialized knowledge. Technical phraseology will be used only when no other word or phrase will convey the intended meaning.

c. Avoid unnecessary words and phrases.

d. Specify limits. When a measurement or adjustment is called for, the optimum value will be stated followed by a tolerance if applicable; for example, 2000±50 yards.

e. Normally, removal and installation procedures shall be complete. Instructions such as reverse removal procedures shall not be used. If a removal or installation procedure is obvious, the primary step shall be given as a command; the details shall not be required. For example, the phrase, “Remove attaching bolts”, is sufficient when the method of removal will be obvious to the technician.

C.3.2 Grammatical person and mode. The second person imperative shall be used for operational procedures; for example, “Remove rammer tank fluid filler can.” The third person indicative shall be used for description and discussion; for example, “Ground indicator light will flash when position of S2 is changed.”

C.3.3 Level of writing. The wording of MRCs shall be for a technician who has a reading ability and comprehension that corresponds to the training experience level of the rate required to accomplish the task.

C.3.4 Consistency. An MRC set shall be prepared to assure technical, logical procedure flow and content of procedure addresses intent of maintenance requirement.

C.3.5 Use of numerals. Use of numerals shall be in accordance with Appendix E.

C.3.6 Nomenclature. Official nomenclature shall be used if assigned. Nomenclature shall be used to provide a consistent description of procedures and equipment. The following requirements will apply:

a. Nomenclature consistency shall be maintained; for example, a part identified as a cover shall not be identified thereafter as a plate.

b. Nomenclature and item name used in the text shall agree with nomenclature and item name on related engineering and design drawings and on identification plates, except it shall be used in its normal reading sequence; for example, Radar Set AN/SPG-55B.

c. When nomenclature is other than official, lowercase letters shall be used; for example, parallax corrector, motor generator, antenna coupler.

d. When two or more items have the same nomenclature, a modifier shall be added to clearly define the function of each item, its distinctive physical properties, or both; for example, signal data converter and frequency converter.

e. The first time an equipment item appears, it shall be identified fully. Further references may omit official nomenclature modifications where there is no possibility of confusion; for example, the name Missile Test Set Mk 1 Mod 1 introduces the equipment by its official nomenclature. Thereafter, the mark and mod designations may be omitted.

f. Where more than one mod of equipment is described, each mod shall be indicated; for example, Magazine Mk 6 Mods 0 and 1.

C.3.7 Capitalization and punctuation. Unless otherwise specified herein, the United States Government Printing Office Style Manual shall be used as a guide for capitalization and punctuation (see Appendix E).

C.3.8 Spelling. Unless otherwise specified herein, the United States Government Printing Office Style Manual shall be the authority for spelling. Words not in the style manual shall be spelled in accordance with Webster's New International Dictionary.

C.3.9 Abbreviations. The use of abbreviations shall be avoided whenever possible. If it is necessary to use an abbreviation, the only abbreviations employed shall be those in common usage and not subject to misinterpretation. Abbreviations that are not in common use and are to be used frequently in an MRC should be clarified when first used by spelling out the word or complete phrase, followed by the abbreviation in parentheses. Abbreviations shall be in accordance with ASME Y14.38, where applicable. Abbreviations not included in ASME Y14.38 shall:

a. Reflect general Navy usage.

b. Be used when no doubt exists as to the interpretation by the rating specified on the MRC.

c. Be approved by the MCA.

C.3.10 Signs and symbols. Signs and symbols shall be as listed in the United States Government Printing Office Style Manual. The following rules shall be observed in the use of symbols:

a. Fire control symbols shall be in accordance with NAVSEA OP1700. Deviations or extensions of these symbols require prior approval by the MCA.

b. Chemical symbols shall not be used unless they form part of the nomenclature. In lieu of symbols, chemical names such as carbon dioxide and hydrogen peroxide shall be used.

c. Graphic symbols shall be in accordance with IEEE 315 for electrical and electronic diagrams, ASTM F856 or ISO-81714-1, as applicable for mechanical parts, and IEEE 91 for logic diagrams.

d. Reference symbols and designations for electrical and electronic parts and assemblies shall be as marked on the equipment (see C.4.1). When not marked on the equipment, they shall be as specified in ASME Y14.44 and supplements thereto.

C.3.11 Warnings, cautions, and notes. Warnings, cautions, and notes shall be used as adjuncts to the text and shall be used as sparingly as possible consistent with safety. If a Warning, Caution, and Note all apply to a step, the order of precedence for these shall be Notes, then Cautions, then Warnings preceding the step. Warnings, Cautions, and Notes are outlined as follows:

a. WARNING: A statement used to call attention to an operating procedure or practice that, if not correctly followed, could result in injury or death.

(1) Warnings shall be listed in the safety precautions block.

(2) Warnings shall be repeated verbatim immediately preceding each step for the procedures involved.

(3) Warnings shall be in the same order in the safety precautions block as they appear in the procedure block.

(4) Maintenance steps that include safety procedures within the step need not be repeated as a warning or listed in the safety precautions block.

(5) Warnings shall not contain procedural steps.

b. CAUTION: A statement used to call attention to a maintenance action that, if not correctly followed, could result in equipment damage.

(1) Cautions shall precede the instruction for the procedure involved, but shall not appear in the safety precautions block.

c. NOTE: Any helpful information that will improve, facilitate, or provide supporting data for a task.

(1) Notes shall not contain procedural steps.

(2) Notes shall be used to amplify R periodicity codes.

(3) Notes shall be used to continue entries too numerous for the space provided by one of the fixed blocks (see C.10).

C.4 REFERENCES

C.4.1 Equipment marking references. References to identifying numbers, switch positions, and panel markings shall be exactly as marked on the equipment; for example, spelling, abbreviations, acronyms, and capitalization. Where necessary, explanations of these markings may be included.

C.4.2 Figure references. The text shall refer to figures which support it. Figures shall be assigned figure numbers (see C.22.4.1). When reference is made to a figure, the reference shall be to the figure number. Figures shall be numbered sequentially starting with figure 1 within each MRC.

C.4.3 Health hazard precaution data references. When hazardous chemicals or other adverse health factors are present in the environment or will appear during the use of the equipment, and these health hazards cannot be eliminated, appropriate warnings shall be included. Necessary protective devices for personnel shall be listed on the MRC in the 'tools, parts, materials, test equipment' block.

C.4.4 Figure item references. Where references are made in a given procedure to several items in the same figure, the figure number need be given only at the beginning of the references. Index numbers, letters, or reference symbols of the references shall be placed in parentheses in the body of the text where pertinent. Care shall be taken that such references are entirely clear.

C.4.5 Measurement references. References to units of measurement shall be specified in the same units to which the equipment was designed.

C.4.6 Model references. The procedural steps shall refer only to equipment covered by the MRC. To facilitate later incorporation of additional models, references to model designations or other unique identifiers shall be held to a minimum consistent with clarity. Any such references made shall be expressed in definite terms, such as model designation, part number, serial number range, or similar means. Such terminology as "on early serial numbers" or "on some late models" is not acceptable.

C.4.7 Other publication references. Each PMS MIP and MRC set shall, to the maximum extent practicable, be a complete, self-contained maintenance entity. Unless otherwise required herein, reference to other publications or instructions shall be approved by the MCA before inclusion in an MRC. References shall be restricted to an extreme minimum so that each MRC shall present a complete planned maintenance tool.

C.4.8 MRC references. When reference is made to text elsewhere within the MRC or to other MRCs, it shall be as specified in C.12.

C.4.9 Specification and standard references. When a Government or military specification or standard is referenced, only the basic number shall be used. The revision letter-suffix shall be omitted unless it is essential. For example, P-C-444, MIL-C-5020, and MIL-STD-105.

C.4.10 Table references. When reference is made to tables, the reference shall be to the table number. Tables shall be numbered sequentially starting with table 1 within each MRC.

C.4.11 Temperature references. Temperature readings shall be written as indicated on the related instrument.

C.4.12 Tools, parts, materials, and test equipment references. All portable and non-installed tools, parts, materials, and test equipment required for the maintenance procedures on the MRC shall be listed under appropriate heading in the 'tools, parts, materials, test equipment' block on the MRC [see 5.1.10.2 r(12)].

C.5 LOCATOR CARDS FOR CLASSIFIED MRCS

An unclassified single page locator card shall be prepared for each classified MRC. The locator card shall be a duplicate of the classified MRC in all blocks except the procedure block. An exception to this rule is when entries in the 'tools, parts, materials, test equipment' block compromise security. For example, a signal generator is listed among the test equipment required; the signal generator operates at a frequency which must be in the frequency of the prime equipment, and the frequency of the prime equipment is classified. In cases of this type, the only entry in the 'tools, parts, materials, test equipment' block will be the phrase "See classified MRC". The procedure block shall include notes that are an extension of the data in the MRC Code and Rates M/H block. One of the following statements shall appear in the procedure block:

a. Maintenance procedure with this requirement is CONFIDENTIAL. Maintenance requirement card is stowed in _______________.

b. Maintenance procedure with this requirement is SECRET. Maintenance requirement card is stowed in ________________.

C.6 SHIP SYSTEM, SYSTEM, SUBSYSTEM, AND EQUIPMENT SECTIONS

These sections shall be filled in as specified below. ESWBS level nomenclature and numbers shall be as specified in 5.1.1.

C.6.1 Ship system section. Enter the ESWBS level 2 nomenclature and number for the functional group containing the item to which the MRC is applicable.

C.6.2 System section. Enter the ESWBS level 3 nomenclature and number for the system containing the item to which the MRC is applicable.

C.6.3 Subsystem section. Enter the ESWBS level 4 nomenclature and number for the subsystem containing the item to which the MRC is applicable.

C.6.4 Equipment section. Enter the ESWBS level 5 nomenclature and the number of the equipment or component to which the MRC is applicable. If the MRC is applicable to the entire subsystem or system, enter ESWBS level 4 or level 3 nomenclature and number as appropriate.

C.7 PERIODICITY

C.7.1 Periodicity numbering. When more than one MRC is prepared with the same periodicity for the same equipment or system, each shall be coded individually; for example, D-1, D-2, D-3. Note that each MRC is assigned a periodicity code; however, one MRC may consist of several pages and include more than one MR. It is not acceptable to have two identically numbered periodicity codes; for example, W-2, W-2R or R-1, R-1W. The developed MRC should cover a specific configuration unless the procedure for multiple configurations and periodicities are identical. When development analysis reveals that a system or equipment should be tested in several modes or configurations and each test can utilize the same procedure, it is unnecessary to provide several MRCs for each mode or configuration. For example, a communication receiver is to be tested to see if it has sufficient sensitivity in each of six frequency bands. The test procedure is the same for each frequency, but the switch setup, the test equipment required, and the desired meter indications may vary from band to band. The following method shall then be used: Include in the preliminary procedure a matrix or a note which associates the switch setup, the test equipment required, and the desired meter indication for each mode or configuration used in the procedure.

C.7.2 R periodicity. Requirements which must be scheduled based on an evolution, event, count, or predictable situation shall be assigned the situation requirement periodicity R. R-scheduling notes are limited to a list maintained by the MCAs and require concurrence of the MCA to deviate. For example, maintenance actions required prior to getting underway, pre-firing tests, or inspection of a shaft and propeller after the ship is in dry dock. The situation requirement code may also be used with a calendar periodicity for certain situations. These situations fall within two general categories:

a. When the situation governs the scheduling of the requirement; for example, R-1W. An example of this type of requirement is a lubrication action that must be performed weekly when a ship is at sea, but is not required while the equipment is idle during an in-port period. This situation calendar requirement would be assigned a code of R-1W, and a note on the MIP and MRC would specify the following: NOTE 1: Accomplish this maintenance requirement when any of the following periodicities or situations occur: a. Weekly while at sea. b. Prior to getting underway.

b. When the calendar periodicity governs the scheduling of the requirement; for example, Q-2R. The Q indicates that the longest time between accomplishments is quarterly and the requirement would be scheduled once each quarter. However, a situation could arise which would dictate that the requirement be accomplished other than as scheduled by the calendar code. When the situation was removed, scheduling would revert to the calendar basis. The calendar situation combination requires a note to explain the situation combination on the MIP and the MRC. The following are some examples of combination calendar and situation requirements:

(1) NOTE 1: Accomplish this maintenance requirement when any of the following periodicities or situations occur: a. Quarterly. b. Every 600±50 hours.

(2) NOTE 1: Accomplish this maintenance requirement when any of the following periodicities or situations occur: a. Monthly. b. 8 hours after each use.

(3) NOTE 1: Accomplish this maintenance requirement when any of the following periodicities or situations occur: a. Semiannually. b. 24 hours after ASW exercises.

(4) NOTE 1: Accomplish this maintenance requirement when any of the following periodicities or situations occur: a. Weekly. b. 24 hours prior to getting underway.

C.7.3 U periodicity. Unscheduled MRCs shall use the letter prefix designator U for the periodicity code. An MRC with a U periodicity shall not be combined with an MRC with a calendar or R periodicity. For equipment with 100 or more UMRCs, the first 99 MRCs shall be numbered U-1 through U-99, and the remaining shall be numbered using a two-character alphanumeric sequence numbering system. This system shall use the letters A through Z, excluding I and O, as the first character and the number 0 through 9 as the second character; for example, U-A0, U-A1, U-A9, and U-B0 instead of U-100, U-101, U-109, and U-110. Adjustment and alignment unscheduled MRCs will begin with U-1 and shall be numbered sequentially. The arrangement of the adjustment and alignment unscheduled MRCs will be in a sequence to allow for the complete realignment of the equipment if required. Unscheduled MRCs shall have a trigger note in order to invoke accomplishment of the MRC. For example, “Accomplish when directed by Q-1 (XXXX)” or “Accomplish when regulator fails to maintain proper pressure”.

C.8 MAINTENANCE REQUIREMENT DESCRIPTION

Each MRC shall have only one MR description. Each MR description shall be numbered. The first letter of the first word in the MR description shall be capitalized with all other words in lower case. When authorized abbreviations or proper nouns are included in the description, they shall be completely capitalized or initially capitalized as appropriate. The MR description shall be a complete sentence (second person imperative) and shall begin with an active verb; for example, inspect, test, calibrate, adjust, lubricate, clean, or replace. The description shall be as brief as possible and shall reflect precisely the task required. The description shall identify what is to be performed, leaving descriptions of performance in the procedure block.

C.8.1 Incidental words. Words such as disassemble, dismantle, remove, or open are incidental to the accomplishment of the requirement and should appear as a setup in the procedure, not in the MR description.

C.8.2 Identification of the complete maintenance action. The MR description shall clearly identify the complete maintenance action. For example, “clean and inspect sump”; “clean and lubricate antenna drive gears”. A simple statement such as “clean radio transmitter” is not acceptable when the MRC procedure includes inspections not associated with cleaning the radio transmitter.

C.8.3 Intent of the maintenance task. The MR description shall reflect the intent of the maintenance task. Use of verbs describing ancillary or incidental functions to the main intent of the task is unacceptable. For example, “clean off grease fittings on fire pump bearing, inject grease with a grease gun, and inspect the old grease expelled”; should be described with the phrase “lubricate fire pump bearings”. Do not use the phrase: “Clean, inspect, and lubricate fire pump bearings”.

C.8.4 Combination of multiple actions into one requirement. Multiple actions shall be combined in one requirement only when they are so related that the accomplishment of one causes the other action to start or the actions are accomplished simultaneously. For example, “1. Clean and inspect sump; replace lube oil filter”.

C.8.5 Exceptions in certain situations. An exception to this situation, however, is an MR description such as, “Inspect internal parts.” This requirement includes the inspection of a quantity of individual items too numerous to attempt to cover in the MR description. Descriptive terminology is needed in the MR description for a complex system or equipment comprised of a number of units. The overall system or equipment title may not be sufficiently descriptive enough to allow positive identification of the unit for which the MR is intended. In this case, the MR description shall include a noun name identification of the unit; for example:

a. “Balance video receiver.”

b. “Measure audio received gain.”

c. “Calibrate transmitter program control circuits.”

d. “Clean and inspect motor-generators.”

C.9 SAFETY

Ensure that all procedures are safe. Whenever possible, maintenance actions shall be accomplished with equipment in a shutdown condition. Procedural steps directing removal of voltage or pressure shall specify the system and equipment nomenclature and refer to the Tag-Out User’s Manual or local tag-out instruction(s). Examples: 1) Turn off Unit 871 and attach safety tag in accordance with the Tag-Out User’s Manual and local tag-out instruction(s). 2) De-energize and isolate ship’s 440 VAC power to the 2A15 power junction box and attach safety tag in accordance with the Tag-Out User’s Manual or local tag-out instruction(s). Where components capable of holding a charge are included in the circuitry, a procedural step shall be provided to direct discharge of such components in accordance with S9086-KC-STM-010/300.

C.9.1 Personal protective equipment (PPE). All safety equipment identified in the ‘tools, parts, materials, test equipment’ block will have procedural steps pertaining to their use (includes harnesses, rubber aprons, respirators, gloves, etc.) included in the step that the PPE is required.

C.10 NOTES

Notes shall be used to supply needed information that is not an action step (see C.3.11). Notes shall be used to amplify R periodicity codes. The note that amplifies the R periodicity code shall be the first item in the procedure block and also appear following the requirement on the MIP. Notes shall be used to continue entries too numerous for the space provided by one of the fixed blocks. Notes shall normally precede the text to which they apply. Notes may follow the text if required for clarity. Excessive verbiage shall be avoided and the note shall be limited to necessary specifics. They shall be sequentially numbered if there is more than one. Tolerances and clearances shall not be given as notes, but shall be included in the procedural step in which they are observed.

C.10.1 MRCs having R periodicity code. MRCs having an R included in the periodicity code shall have Situational Requirement notes as specified in C.7.2. This note shall be the first item in the procedure block and also appear following the requirement on the MIP.

C.10.2 MRC procedural exceptions. When a block of an MRC is too small to enclose all required entries, insert in parentheses the phrase “(see NOTE 1)”. In that note, list the entries normally made in the block. For this purpose, rates and M/H shall be considered as one block and the total M/H and elapsed time entered in their assigned space.

C.11 WARNINGS AND CAUTIONS

Warnings and cautions shall be included as necessary in the procedure block as specified in C.3.11. Warnings and cautions shall not be numbered.

C.12 REFERENCES

References to other publications shall be as specified in C.4.7. References to text elsewhere within the MRC or to other MRCs shall be as follows:

a. When writing procedural steps, it is permissible to use the phrase “repeat step(s)”. The reference shall be to procedural step numbers only; for example, “repeat steps 2.d. through 2 f. to ensure accurate measurement”. Unless the sequencing is very clear and understandable, the phrase “repeat step(s)” should not be used. Repeat steps which send the reader to a step which is already a repeat step shall not be used.

b. When certain MRCs are to be accomplished in a specific sequence in the subject MRC, those MRC(s) may be referenced to avoid repetition. The referenced MRC may have a calendar, R, or U periodicity. The subject MRC shall list the referenced MRC(s) as related maintenance in the ‘tools, parts, materials, test equipment’ block. The following applies:

(1) The referenced MRC shall be accomplished in its entirety, and it shall:

(a) Be referenced as a step in the procedure; for example, “Perform MRC Q-1”.

(b) Appear in the tools, parts, material, test equipment block; for example, “[02000] Mandatory Related Maintenance (Q-1 (ABCD)), where ABCD is the MRC SYSCOM”.

(c) Appear in the related maintenance column on the MIP; for example, as Q-1#, with the following notation on the MIP, following the scheduling aid: # Mandatory scheduling required.

C.13 FILL-IN BLANKS

Fill-in blanks are justified in the procedure when the data concerns values that vary from ship-to-ship due to installation or configuration variances.

a. Two categories of blanks subject to fill-ins are acceptable for use in the procedure block of an MRC when approved by the applicable MCA.

(1) Fill-ins for values or locations which are pertinent to the procedural step and which vary from installation to installation.

(2) Those blanks which require fill-in data to complete the blocks of a table from which other communications are made. A horizontal line of the appropriate length shall be inserted in the proper location to accommodate the fill-in information; for example:

Add the following values to determine MDS:

(a) Signal generator output attenuator _______dBm

(b) RF cable attenuation _______dB

(c) Directional coupler attenuation _______dB

C.14 PRELIMINARY

When steps are necessary to prepare the system or equipment for the maintenance action(s) prior to beginning the MR, the MRC will contain a preliminary procedure. Typical preliminary steps are: energizing equipment, warming-up equipment, positioning switches, opening doors, performing electrical isolation, tag-out of equipment, preparing cleaning solutions, establishing communication, preparing setup of test equipment, and ensuring safe conditions.

a. Preliminary steps shall be listed under the heading “Preliminary” and shall appear before the first MR description.

b. The first letter of the word “Preliminary” shall be capitalized, the entire word in boldface, and it shall not be punctuated.

c. The word “Preliminary” shall be followed by a minimum of one line of text before continuing to the second page. If space does not permit the one line of text, the preliminary heading shall be started on page 2 of the MRC.

d. Preliminary steps are preparation actions and shall not include disassembly or other action steps that are part of the requirement.

e. Steps in the preliminary procedure will be identified by alphabetical letters in lower case and punctuated by a period. For example, a., b., c.

f. Preliminary information shall be concise and presented as “do steps”. Tables, figures, and notes may be included as required.

g. The time required to accomplish these steps shall be included in the man-hours calculation.

h. For system-level MRCs, the preliminary steps may also include a matrix listing equipment with manning requirements, matrix for alternatives, and similar information.

C.15 MAINTENANCE REQUIREMENTS

Maintenance requirement descriptions from the MR description block shall be repeated, word-for-word, and all words except articles, conjunctions, and prepositions shall be initially capitalized (see Appendix E).

a. Each MR description shall be boldface; for example, “**Clean, Inspect, and Lubricate Fueling Rig Blocks and Fittings**”. Following the MR description, list the step-by-step procedure. The format shall be as specified in C.22.3.

b. For MRCs which require “orders” and “responses”, procedural steps may be prepared in columnar format. When clarity will be improved, indicate where the task is to be performed. For example, “d. At UD 101, position S305 to OFF”.

c. If procedure evaluation concludes that a close-out statement dependent on the ship’s operational readiness condition is required, use the statement “Return equipment to readiness condition.” Use of this statement does not release the developer from including procedural steps which return equipment to the condition in which it stood before commencing the MR. The close-out phrase is not to be used as a “catchall”. For example, reinstalling covers removing test equipment or removing safety tags.

C.16 FIGURES

Figures may be used when they present procedural data more clearly than text. Figures used in lieu of text shall constitute an integral part of the procedure and shall be clearly related within the text. Figures used to augment the text shall depict exactly the condition described in the text. Location instructions shall be as specified in C.22.4.1. The MDA shall attach a copy of the figure to the MRC verification draft and indicate on the figure the MRC and the step(s) to which it applies. Figures will be in the form of original line art unless otherwise authorized by the MCA.

C.16.1 Line art standards. Line drawings shall be delivered in a digital format and shall conform to the following:

a. Size. An art filename is an eight-character filename where the first two characters represent the size, the next four are the MRC SYSCOM number, and the last two are the figure number associated with a graphic when first entered in the MRC, although it may not reflect the correct numerical order if a graphic is being added to an MRC which contains existing figures. Art file sizes can be from A1 through A6. The assigned size is determined by the amount of the page that is taken by the graphic. A page is divided into 6ths, with size A1 being one-sixth of the page and a size A6 being the entire page. Sizes A2 through A5 are the respective amount for that number of sixths as a portion of the page. Unless otherwise authorized by the MCA, artwork will be the same size as the area it will occupy on the MRC. Art work should be positioned so that it can be read in the same plane as the procedural step (see figure C-1). When this cannot be done, the illustration shall be positioned so that a 90-degree clockwise turn of the MRC page will place the illustration in the proper attitude for viewing (see figure C-2). A minimum of ¼ inch shall be allowed between illustrations and adjacent text and borders. If it cannot be legibly reproduced in this manner, it shall be divided for production into two or more figures.

b. Standards. Artwork will be done using black lines on a white matte background extending the full width of the artwork with no outer border. Line widths on the artwork shall not be less than 0.005 inch (5 mils). Adjacent line separation should be 0.010 inch (10 mils) or more. Captions, callouts, legends, and footnotes shall be in boldface capital letters equal in size to 10 points or more.

C.16.2 Halftones. Halftones will only be authorized by the MCA when photographs are the only medium that can clearly convey the required information to shipboard personnel. When used, halftones shall be screened (85 line, 35 percent shadow dot, 15 percent highlight dot).

C.17 TABLES

Tables will be used to present data when the data can be presented more clearly in tabular form. References in the procedural block shall make the purpose of the table clear. Tables of one line shall not be used; instead, the information shall be presented in a procedural step. Tables shall be located as specified in C.22.5.1.

C.17.1 Table size. A ½-inch space maximum shall be allowed vertically between tables and adjacent text and a ¼-inch space minimum shall be allowed horizontally. When a table is of such a size that it cannot be legibly reproduced within the prescribed image area, it shall be divided for reproduction as two or more tables.

C.18 MRCS FOR SYSTEM OPERABILITY TEST (SOT)

The intent of the MRC for SOTs is to provide a fully detailed test procedure to the maintenance personnel in as understandable a format as possible. To achieve this goal, it may be necessary to include artwork on the MRC document showing the different complex switch and test equipment arrangements for each test to be performed. Furthermore, it is a requirement that MRCs for SOTs explain the exact procedures for the actual system configuration on each ship. References to other documents and reliance of maintenance personnel's knowledge of system setup procedures are unacceptable. MRCs for SOTs shall comply with the requirements as specified in the acquisition document.

C.19 PREPARATION OF MRCS FOR IEM

MRCs for IEM are generated only when:

a. IEM analysis identifies requirements not available in existing PMS or not projected for development after scheduled maintenance requirement analysis.

b. A scheduling MRC is needed as specified in C.19.2.

C.19.1 Inactive equipment maintenance procedure MRCs. MRCs required to provide maintenance procedures for IEM that are not available as scheduled MRC(s) shall be developed as specified by the MCA.

C.19.2 Inactive equipment maintenance scheduling MRC. Normally, information pertaining to the scheduling of IEM will be included on the MIP by citing MRCs and providing supporting information in the form of scheduling notes. However, some complex equipment may require a large number of MRs combined with scheduling notes to control sequencing of scheduling. In these cases, an IEM scheduling card shall be prepared (see figure C-3). The scheduling card shall provide scheduling information only and shall not include maintenance procedures. Block content of the scheduling card shall be in accordance with the following:

a. Ship system, system, subsystem, and equipment blocks. Entries shall be in accordance with 5.1.10.

b. MRC code block entries shall be in accordance with 5.1.10.

c. Rates, M/H, total M/H, and elapsed time blocks. Entries shall be in accordance with 5.1.10.2.o.

d. Maintenance requirement description block. This block shall describe the type of maintenance scheduling information. For example, "1. Perform Lay-up Maintenance."

e. Safety precautions block. The standard entry in this block shall be as follows: 1. Observe safety precautions as specified on scheduled MRCs.

f. Tools, parts, material, test equipment block. Entries shall list the mandatory related maintenance being scheduled by this scheduling MRC.

g. Procedure block. The first entry shall be a note; for example, "NOTE: This is a scheduling card. Schedule and perform listed MRCs for (LU, PM, SU, or OT, as appropriate)." The entry following the note shall be the MR description. Each step following the MR description shall be a statement of what is to be accomplished, followed by the reference to the appropriate MRC or document containing the procedures (see figure C-3). Notes may be used to provide such information as sequencing, special personnel, and services requirements.

C.20 SCHEDULING AIDS

All notations affecting the scheduling of MRs shall be located in the MR column preceding the first MR description. Scheduling aids that are on an MIP which are applicable to one or more MRCs will also be on each applicable MRC as a Note. The use of a generic scheduling aid such as "Review all MRCs; omit MRCs not applicable" or variations of that statement will not be used. MRC applicability to specific configuration should be addressed listing the specific periodicity of the affected procedures.

a. When scheduling aids include more than one topic, they shall be numbered under a scheduling aid heading; for example:

Scheduling aids:

(1) MRC 3H5F (Q-3) applies to APL 88008293472389 only. Review and omit MRC if not applicable to your configuration; no feedback report required.

(2) MRCs 8F9G (A-9) and 9J7V (A-11) apply to DDG 72-89. Review and omit MRCs if not applicable to your configuration; no feedback report required.

b. An asterisk and the symbol # will be used to call attention to specific scheduling information as follows:

* This is a Safety of Ship item.

Mandatory scheduling required.

The generic statement "Review and omit MRCs not applicable to your configuration; no feedback report required" shall not be used.

C.21 PAGE NUMBER

All sheets that comprise one MIP shall be identified by completing the entry "Page ____ of ____" on the bottom of the sheet.

C.22 COMPOSITION AND LAYOUT REQUIREMENTS

C.22.1 Type size and face. Unless otherwise specified (see 6.2), 12-pitch spacing, approximately 10-point type face (for example, Times New Roman or equivalent face and size) shall be used to type information on the MRC and MIP forms. Security classification, when required, shall be placed on both verification (review) and camera ready copy in boldface capital letters equal in size to 14 point.

C.22.2 Spacing. Maintenance procedure text copy on MRC forms shall be prepared in single column or multicolumn format. Single spacing shall be used between steps except where the acquisition document (see 6.2) or MCA specifies double spacing to enhance readability. Spacing requirements for multicolumn format shall be as specified in C.15. A double space shall precede and follow notes, cautions, warnings, and columns with heading titles. The left margin on MRCs shall always be one space in from the left borderline. There shall be an exception when it is necessary to list 10 or more items in the first column of the ‘tools, parts, materials, test equipment’ block; in this case the left margin spacing for that particular page of the MRC shall be two spaces in from the borderline, so that there is always a full space between the left borderline and any typed material. All typed material on an MRC shall be arranged to align with this margin. MIPs shall be prepared with single spacing between lines of a given MR entry. A double space shall separate MRC entries.

C.22.3 Indentation and numbering of text. Following the MR description, the step-by-step procedure shall be entered in continuous numerical and alphabetical sequence, using the following letters and numbers to identify steps and sub-steps as necessary:

Set margin stop 2 spaces in procedure

1. The Maintenance Requirement Description

   a. Procedural step

      (1) Procedural substep

         (a) Procedural substep

            -1- Procedural substep

               -a- Procedural substep

Set 1st tab 5 spaces in

Set 2nd tab 8 spaces in

Set 3rd tab 12 spaces in

Set 4th tab 16 spaces in

Set 5th tab 20 spaces in

When the alphabet is used through z and steps still remain to be identified, continue: “aa”, “ab”, and “ac”. When “az” is reached, continue “ba”, “bb”, and “bc”. The second and succeeding lines of any step shall be flush left-aligned with the first line of that step.

C.22.4 Figures. Figures shall be used only when essential to illustrate a clear presentation of the maintenance procedure (see C.16). Figures shall be in accordance with MIL-STD-38784.

C.22.4.1 Figure location. Figures shall be positioned so that they lie in the same reading plane as the procedural steps (see figure C-1). When this cannot be done, figures shall be positioned so that a 90-degree clockwise rotation of the MRC will position the figure for normal viewing (see figure C-2). Artwork should be placed following the procedural step to which it refers; however, it is unacceptable to allow large blank spaces or to otherwise waste space because of artwork placement throughout the MRC solely to cause the illustration to follow a specific procedural step. If illustrations are large and their location would interfere with correct sequencing of procedural steps and cause difficulty in understanding of interpretations, they may be placed in numeric sequence on pages at the end of the procedure.

C.22.5 Tables. Tables shall be used to present data when the data can be presented more clearly in tabular form. Elaborate or complicated tables shall be avoided. Lines shall be used between columns only. Tables shall be numbered; for example, table 1. A descriptive title shall be added when required for clarity in the procedure. The table number and title shall be placed below the table. Positioning instructions are the same as for figures (see C.22.4.1).

C.22.5.1 Table location. A table should be placed following the procedural step containing the first reference to it. When this is not possible because of space limitations, it may be placed at the beginning of a succeeding page, on a separate page, or at the end of the procedural steps. When table(s) and figure(s) are sequential, the table(s) shall precede the figure(s).

C.22.5.2 Troubleshooting tables. When test MRCs contain tables designed to assist in locating troubleshooting fault isolation procedures applicable to malfunctions discovered during the test accomplishment, the table shall be located at the end of the procedure block. As a minimum, the table shall identify the procedural steps applicable, publication number containing the troubleshooting or fault isolation procedure, and identifying information for the applicable procedures within the technical publication. Specific page or paragraph numbers of the referenced publication shall not be provided.

C.23 VERIFICATION

C.23.1 In-process review. The MCA may perform in-process reviews, where necessary. The MDA shall provide support and materials as required to facilitate in-process reviews specified in the acquisition documents.

C.23.2 Planned maintenance system development activity quality program requirements. The MDA shall establish and maintain a quality assurance program to ensure that the editorial quality, technical accuracy, correctness of composition, and graphic quality are consistent with the requirements of this standard. The quality assurance check sheets (see figure C-4) exhibit minimum recordkeeping requirements for MRCs and UMRCs needed to administer this portion of quality assurance.

C.23.2.1 Quality program organization. Effective management for quality shall be clearly defined by the MDA. Personnel performing quality functions shall have the responsibility, authority, and organizational freedom to identify problems and to initiate, recommend, and provide solutions. Management shall review the status and adequacy of the program throughout each development phase.

C.23.2.2 Initial quality planning. The MDA, during the earliest practical phase of contract performance, shall conduct a complete review of the development requirements. This review shall identify and make timely provisions for any special skills, processes, methods, and procedures to assure the quality of the development and the preparation, inspection, verification, and validation of the documentation.

C.23.3 Government-furnished material and data. The MDA shall conduct a review of Government-furnished material and data to determine compliance with the terms of the contract and the adequacy of the source material. The MDA shall report deficiencies which will impair the quality of the planned maintenance procedures to the MCA.

C.23.4 Inspection of documentation. Documentation that is submitted by terms of the acquisition document as deliverable items shall be inspected by the MCA for compliance with sections 4 and 5.

Date: May 2003	MIP Series: 2411	MRC: 53 2NJE N	Periodicity: A-1

PROCEDURE

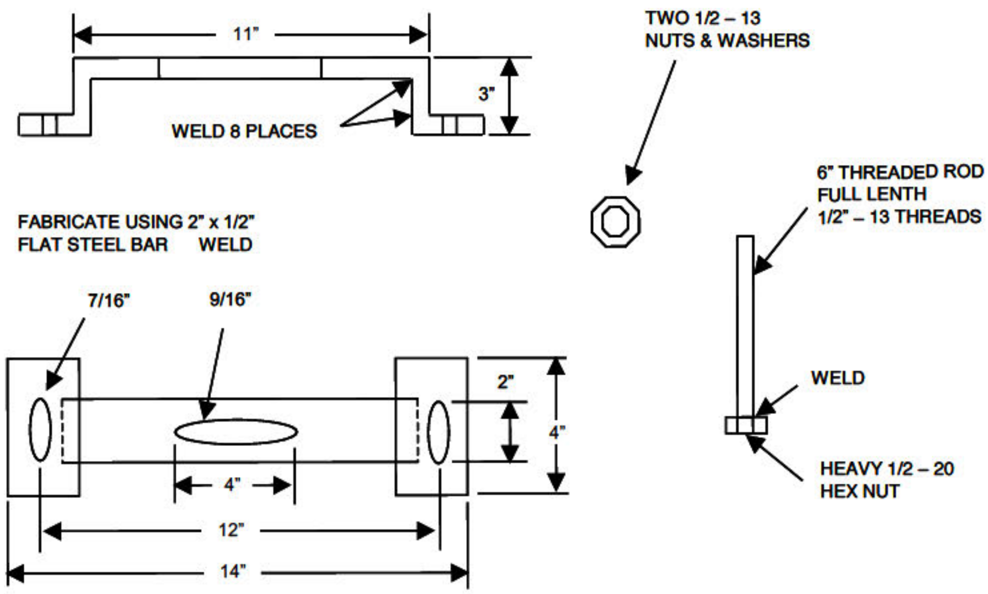

Figure 1

Maintenance Requirement Card (MRC) OPNAV 4790/85	Page 2 of 2	SYSCOM:

FIGURE C-1. Sample portrait art on MRC.

Date: May 2003	MIP Series: 2411	MRC: 53 2NJE N	Periodicity: A-1

PROCEDURE

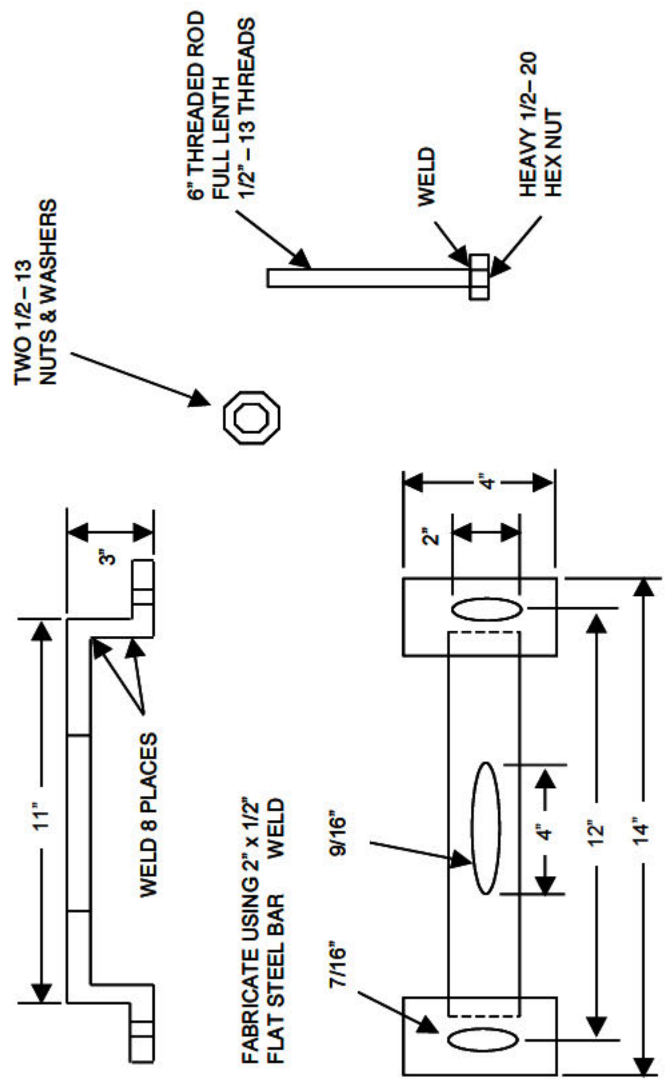

Figure 1

Maintenance Requirement Card (MRC) Page 2 of 2 SYSCOM:
OPNAV 4790/85

FIGURE C-2. Sample landscape art on MRC.

DISTRIBUTION STATEMENT A:

Approved for public release; distribution is unlimited.

Date: June 2012	**MIP Series:** 1234	**MRC:** 62 WXY9 N	**Periodicity:** SU-1

Location:

Ship System:	Interior Communications 1000
System:	Recording and Television Systems 1200
SubSystem:	Television, Closed Circuit - Tactical Data Processing 1230
Equipment:	CCTV Set 1234

Rates	Man-Hours	Rates	Man-Hours	Rates	Man-Hours
PO2	0 1				
Total Man-Hours:	0 1	**Elapsed Time:**	0 1		

MAINTENANCE REQUIREMENT DESCRIPTION

1 Perform Start-Up Maintenance

SAFETY PRECAUTIONS

1 Forces afloat comply with Navy Safety and Occupational Health (SOH) Program Manual for Forces Afloat, OPNAVINST 5100 19 series

TOOLS, PARTS, MATERIALS, TEST EQUIPMENT

MISCELLANEOUS

1 [02000] Mandatory Related Maintenance MRC (A-1 (WXYZ))
2 [02000] Mandatory Related Maintenance MRC (A-2 (WXY3))
3 [02000] Mandatory Related Maintenance MRC (A-3 (WXY4))
4 [02000] Mandatory Related Maintenance MRC (U-1 (XX77))

NOTE: Numbers in brackets can be referenced to Standard PMS Materials Identification Guide (SPMIG) for identification

PROCEDURE

1. Perform Start-Up Maintenance.

a Schedule and perform MRC A-1 (WXYZ)
b Schedule and perform MRC A-2 (WXY3)
c Schedule and perform MRC A-3 (WXY4)
d Schedule and perform MRC U-1 (XX77)

Maintenance Requirement Card (MRC) Page 1 of 1 SYSCOM: 62 WXY9 N
OPNAV 4790/85 (REV. 9-97)

FIGURE C-3. IEM scheduling MRC (start-up).

SYSTEM/EQUIPMENT					MIP Series	MRC No
PRELIMINARY		FINAL		No	DESIRED STANDARD CONDITION	Reference
Checked By	Date	Checked By	Date			
				1	Correct nomenclature is in Ship System, System, Subsystem, and Equipment blocks.	MIL-STD-3034A (C.6)
				2	ESWBS level is in Ship System, System, Subsystem, and Equipment blocks.	MIL-STD-3034A (C.6)
				3	Correct MIP series listed.	MIL-STD-3034A (5.1.10.2.n)
				4	Correct periodicity code listed.	MIL-STD-3034A (5.1.10.2.n)
				5	Rate block(s) is/are properly filled in.	MIL-STD-3034A (5.1.10.2.o)
				6	M/H block is properly filled in.	MIL-STD-3034A (5.1.10.2.o)
				7	Preliminary time is included in M/H block.	MIL-STD-3034A (5.1.10.2.o)
				8	Total Man-hours block is correctly computed and properly filled in.	MIL-STD-3034A (5.1.10.2.p)
				9	Elapsed Time block is correctly computed and properly filled in.	MIL-STD-3034A (5.1.10.2.q)
				10	MR Description block is properly filled in (complete sentence, second person imperative and beginning with an action verb).	MIL-STD-3034A (5.1.10.2.l, C.8)
				11	Safety Precautions block is properly filled in (first precaution refers to a manual or instruction).	MIL-STD-3034A (5.1.10.2.m)
				12	All other specific warnings in Safety Precautions block are in the same order in which they appear in the procedure block.	MIL-STD-3034A (5.1.10.2.m.(1))
				13	Cautions do not appear in Safety Precautions block.	MIL-STD-3034A (C.3.11.b)
				14	For submarine applications, Safety Precautions block contains re-entry control statement as required.	MIL-STD-3034A (5.1.10.2.m.(4))
				15	When scope of certification items are impacted, ensure compliance with DSS-SOC re-entry Control Procedures of SS800 AG MAN-010/P-9290 (with the appropriate DSS-SOC Notebook).	MIL-STD-3034A (5.1.10.2.r.(7))
				16	Safety Precautions block contains cleaning solvent statement when required.	MIL-STD-3034A (5.1.10.2.m.(5))
				17	Safety Precautions block contains the "Do Not Work Alone" statement, and Rates/MH blocks contain the suitable number of personnel, when required.	MIL-STD-3034A (5.1.10.2.m.(2), 5.1.10.2.o, 5.1.10.2.p)

FIGURE C-4. Quality assurance check sheet.

PRELIMINARY		FINAL		No	DESIRED STANDARD CONDITION	Reference
Checked By	Date	Checked By	Date			
				18	Tools, Parts, Materials, Test Equipment (TPME) block is properly filled in, in the following order: test equipment, materials, parts, tools, and miscellaneous.	MIL-STD-3034A (5.1.10.2.r)
				19	Tools, Parts, Materials, Test Equipment (TPME) is numbered and identified by the applicable Standard PMS Materials Identification Guide (SPMIG) number when available.	MIL-STD-3034A (5.1.10.2.r)
				20	SCAT codes and nomenclature for test equipment are listed.	MIL-STD-3034A (5.1.10.2.r.(12).(a))
				21	Tools called out in procedure match nomenclature of tools listed in TPMTE.	MIL-STD-3034A (5.1.10.2.r.(8))
				22	Materials and lubricants are identified by government or manufacturer specification number, item name, and nomenclature.	MIL-STD-3034A (5.1.10.2.r.(13).(b))
				23	Page number block is properly filled in.	MIL-STD-3034A (C.21)
				24	Repair parts are properly listed.	MIL-STD-3034A (5.1.10.2.r.(12).(b))
				25	Equipage and special materials are properly listed.	MIL-STD-3034A (5.1.10.2. r.(12).(e))
THE FOLLOWING CHECKS CONCERN PROCEDURE BLOCK						
				26	All Personal Protective Equipment (PPE) identified in the 'tools, parts, materials, test equipment' block will have procedure steps pertaining to their use (includes harnesses, rubber aprons, respirators, gloves, etc.) included in the step that the PPE is required.	MIL-STD-3034A (C.9.1)
				27	When SUBSAFE boundaries are to be violated, ensure compliance with SUBSAFE Re-entry Control Procedures of 0924-062-0010 or COMFLTFORCOMINST 4790.3, Volume V, as applicable. When scope of certification items are impacted, ensure compliance with DSS-SOC Re-entry Control Procedures of SS800 AG MAN-010/P-9290 (with the appropriate DSS-SOC Notebook).	MIL-STD-3034A (5.1.10.2.r.(7))
				28	Classification markings, if applicable, are properly filled in.	MIL-STD-3034A (C.5)
				29	Language, sentence structure, steps, and terminology meet standard criteria.	MIL-STD-3034A (C.3.1-C.3.10)
				30	Notes are not used for action steps.	MIL-STD-3034A (C.10, C.3.11.c)
				31	Notes are numbered if MRC contains more than one.	MIL-STD-3034A (C.10)

FIGURE C-4. <u>Quality assurance check sheet</u> – Continued.

PRELIMINARY		FINAL		No	DESIRED STANDARD CONDITION	Reference
Checked By	Date	Checked By	Date			
				32	Situation Requirements are in accordance with current approved list.	MIL-STD-3034A (C.7.2)
				33	WARNINGs address personnel safety; CAUTIONs address equipment damage.	MIL-STD-3034A (C.3.11.a, C.3.11.b)
				34	Warnings and cautions preceded applicable step in which hazard is encountered.	MIL-STD-3034A (C.3.11, C.11)
				35	Repeat steps are used properly.	MIL-STD-3034A (C.12.a)
				36	References to other publications are restricted.	MIL-STD-3034A (C.4.7)
				37	Scheduled MRC references are properly made.	MIL-STD-3034A (C.4.8, C.12)
				38	Unscheduled MRC references are properly made.	MIL-STD-3034A (C.7.3)
				39	Fill-in blanks are used properly.	MIL-STD-3034A (C.13.a.2)
				40	Related Maintenance identified.	MIL-STD-3034A (C.12.b.1)
				41	All initial “make ready” steps, such as energizing equipment, warming-up equipment, positioning switches, opening doors, performing electrical isolation, tag-out of equipment, preparing cleaning solutions, establishing communication, preparing setup of test equipment, and ensuring safe conditions are included in Preliminary.	MIL-STD-3034A (C.14)
				42	If applicable, identify any special plant or equipment conditions that must be in place and ensure they are included in Preliminary Section.	MIL-STD-3034A (C.14)
				43	MR description is exactly as in MR Description block with initial capitals and underlines, or in boldface.	MIL-STD-3034A (C.15)
				44	Procedural steps directing removal of voltage or pressure specify the system and equipment nomenclature and refer to the tag and untag procedures for equipment or system in accordance with Tag-Out User’s Manual, NAVSEA S0404-AD-URM-010/TUM, or local tag-out instruction(s).	MIL-STD-3034A (C.9)
				45	All steps within each MR are in continuous alpha-numerical sequence.	MIL-STD-3034A (C.22.3)
				46	Inspection and measurement steps clearly specify limits so that a condition can be easily determined to be acceptable or unacceptable.	MIL-STD-3034A (5.1.10.2.s.(6))
				47	Tables are numbered and referenced in text.	MIL-STD-3034A (C.17, C.22.5)

FIGURE C-4. Quality assurance check sheet – Continued.

PRELIMINARY		FINAL		No	DESIRED STANDARD CONDITION	Reference
Checked By	Date	Checked By	Date			
				48	Electrical panels, circuit breakers, and valves identified by name or number identified for tag-out procedures.	MIL-STD-3034A (5.1.10.2.s.(8))
				49	Close-out statement is included at completion of procedure if applicable.	MIL-STD-3034A (C.15.c)
				50	Procedural steps are factual and concise, and are not susceptible to misinterpretation.	MIL-STD-3034A (5.1.10.2.s, C.3.1)
				51	Optimum value is stated, followed by a range, when a measure or adjustment is specified.	MIL-STD-3034A (C.3.1)
				52	No words are misspelled.	MIL-STD-3034A (C.3.8)
				53	Abbreviations used are those in common usage and not subject to misinterpretation, and abbreviations that are not in common use and are to be used frequently in an MRC should be clarified when first used by spelling out the word or complete phrase, followed by the abbreviation in parentheses.	MIL-STD-3034A (C.3.9)
				54	Signs and symbols are standards.	MIL-STD-3034A (C.3.10)
				55	Figures are numbered and referenced in text.	MIL-STD-3034A (C.22.4)
				56	Spacing and format meet standard criteria.	MIL-STD-3034A (C.22.2)
				57	Preferred words and expressions are used.	MIL-STD-3034A (Appendix E)
				58	Capitalization meets standard criteria.	MIL-STD-3034A (C.3.7, Appendix E)
				59	Line art meets standards.	MIL-STD-3034A (C.16)
				60	General Electrical Safety requirements noted in WARNINGS throughout the procedure where applicable.	NSTM Chapter 300 (2.3.1.2)
				61	Safety precautions and procedures for working on energized equipment are incorporated.	NSTM Chapter 300 (2.4)
				62	HAZMAT requirements noted in WARNINGS throughout the procedure where applicable.	NSTM Chapter 670 (Volume 2)

FIGURE C-4. Quality assurance check sheet – Continued.

BACKFIT RELIABILITY CENTERED MAINTENANCE

D.1 SCOPE

D.1.1 Scope. This appendix describes the steps taken and the forms used to validate the adequacy of existing maintenance programs for systems, subsystems, and equipment for which there is a significant body of operational and maintenance history. The objective of applying Backfit RCM to a system and its subsystems and equipment is to establish the right maintenance, performed on systems or equipment that will benefit from it, and perform this maintenance when it is needed. This Backfit RCM process follows the requirements identified in 4.3 and 4.4. This Appendix is a mandatory part of the standard. The information contained herein is intended for compliance.

D.2 INFORMATION COLLECTION

The analyst should gather necessary technical information for each system to be analyzed and its associated equipment for all applicable configurations under analysis to include:

a. Existing maintenance

b. Previous RCM analysis data

c. Failure data

d. Technical manuals or other technical data, as needed

e. Prognostic and diagnostic CBM data

Acquisition and distribution of this information may be handled as a specific assignment under the direction of the activity managing the review.

D.3 BACKFIT RCM METHODOLOGY

D.3.1 Classic RCM. The classic RCM methodology in this standard is used to develop applicable and effective maintenance tasks for new systems, subsystems, and equipment during asset acquisition and as the asset is modernized during its service life. However, initial task development is only the first step in developing a good maintenance program. No maintenance program should remain static. Successful maintenance programs build on operational experience in a program of continuous improvement that leads toward an optimized set of maintenance tasks over time.

D.3.2 Backfit RCM. Backfit RCM is a methodology to validate existing approved maintenance requirements by using Backfit RCM logic combined with operational experience and failure data (if available). The methodology first looks to see if the system does really experience age degradation; that is, the assumed failure modes do, in fact, occur. If there is a history of age degradation, the current tasks are analyzed for applicability and effectiveness. If the assumed failure modes do not occur in the absence of preventive maintenance, then the existing maintenance requirements tasks serve no useful purpose and can be eliminated.

D.4 CONDUCTING A BACKFIT RCM ANALYSIS OF AN EXISTING PLANNED MAINTENANCE PROGRAM

Steps in this paragraph correspond to figure D-1, and blocks correspond to figure D-2.

D.4.1 Decision tree. The Backfit RCM methodology uses a decision tree or road map (figure D-1) with consideration to the areas of reliability degradation, task applicability, task effectiveness, and recommending change. The seven steps are applied in a manner similar to that described in section 5 for Classic RCM. This process validates existing maintenance requirements using basic maintenance concepts and operational experience.

D.4.2 Process steps. There are seven primary steps to the decision process involved in Backfit RCM. The quality of the results from applying the decision logic depends considerably on the understanding of each step. Therefore, we will consider each step in some detail. Record results of each process step in the specified location on the Backfit RCM analysis form (figure D-2).

a. Header information. Complete the header section (blocks 1-7) for the Maintenance Task being evaluated.

b. Block 1 – Control number. Enter the unique identification code of the maintenance task under review (that is, for PMS, enter MIP control number and MRC control number separated by a slash (MIP/MRC); or for Class Maintenance Plan tasks, enter the CMP task number).

c. Block 2 – System. Enter the nomenclature of the associated system or subsystem.

d. Block 3 – Task Description. Enter the maintenance task description or summary. For PMS MRCs with more than one task description, use a separate Backfit analysis form for each task description.

e. Block 4 – Periodicity. Enter the task periodicity or calendar frequency.

f. Block 5 – Prepared by. Enter the analyst's name and the date.

g. Block 6 – Reviewed by. Reserved for the first level reviewer's printed name, signature, and date.

h. Block 7 – System ISE or TA. Enter the name and phone number of the system In-Service Engineer (ISE) or other technical authority (TA). The technical authority is established for the system prior to the review. For Navy ship systems the technical authority will normally be the In-Service Engineer.

D.4.3 Step 1. Identify the functional failure and failure mode that the existing task is intended to prevent. Each maintenance task is designed to prevent (condition-directed, time-directed, servicing, and lubrication tasks) or to identify (failure finding tasks) a failure mode.

a. For each maintenance task, the analyst identifies the functional failure and failure mode that the task is intended to prevent. Classic RCM identified probable failures and failure modes. Backfit RCM analysis uses operational experience to address the failure modes that each maintenance task was designed to prevent. Remember that failure modes are causes of functional failures, while functional failures can be viewed as the effect of what happens to a system or equipment. The failure mode is the material condition at the point of failure. Preventive maintenance tasks are intended to prevent specific failure modes that result in functional failure.

b. Block 8 – Functional failure. Enter the functional failure.

c. Block 9 – Failure mode. Enter the failure mode.

D.4.4 Step 2. Does a significant rate of age degradation exist?

Using 3-M data and other operational information, the analysts determine whether or not the failure mode actually occurs.

Based upon your operational and professional experience, how likely is it that this failure mode will occur within the service life of the equipment? Would the failure mode occur in service life barring the performance of the maintenance task? This separates the failure modes into two groups:

a. Yes. Age degradation does exist and the failure mode would be likely to occur without a preventative task or if the analyst is unsure of the occurrence of the failure mode.

b. No. The item does not degrade meaningfully with age or the degradation is sufficiently slow as to be of no practical concern. There is no need for the task, and it can be deleted.

c. Block 10 – Age degradation. Enter "Y" or "N" corresponding to the answer determined in this step. If the answer is no, mark "Delete Task" in the change recommendations section (block 15). The analysis for this task is then complete. Rationale for this deletion must be entered in block 16.

D.4.5 Step 3. Determine and classify the type of maintenance task.

Determination of the type of maintenance task is important because the rules that are applied to evaluate task applicability differ depending on task type.

Some procedures may attempt to accomplish more than one task. In these cases the analyst must evaluate each task independently to ensure each meets the appropriate rules of applicability and effectiveness. Additional consideration should be given to simultaneous performance of the tasks resulting in improvements that would make a task which is either non-applicable or non-effective on its own become applicable or more commonly effective when performed in combination.

Remember that all tasks are scheduled, not just those few that are time-directed life-renewal maintenance tasks; and, scheduling of the task has no bearing on the task type classification. As specified in 5.1.5.4, there are five types of preventive maintenance tasks:

a. Condition-directed tasks renew life based on objective, observable evidence of need (that is, based on a measured condition compared with a standard).

b. Time-directed tasks renew life based on statistical analysis of population wearout regardless of actual condition.

c. Failure finding tasks determine whether or not a hidden functional failure has occurred.

d. Servicing tasks add or replenish materials consumed as part of, and necessary for, the functionality of the equipment or system (for example, paper in a computer printer, toner in a copy machine, or fuel in an engine). Mechanical filter maintenance, replenishment through cleaning or replacement (for example, air, oil, and water) may be included as a servicing task.

e. Lubrication tasks oil, grease, or otherwise lubricate machinery.

f. Block 11 – Task type. Enter the task type.

D.4.6 Step 4. Is the existing maintenance task applicable?

An applicable task is one that restores or maintains the inherent equipment, system, or component reliability. The task is determined to be applicable if it satisfies all of the rules for its task type. Remember that each type of task has its own specific rules for applicability.

a. Condition-directed. Condition-directed tasks are applicable only if:

(1) An equipment characteristic corresponding to the specific failure mode can be identified, and

(2) The potential failure can be measured accurately with consistency, and

(3) Enough time exists between potential and actual failure to take corrective action.

b. Time-directed. Time-directed tasks are applicable only if:

(1) The item exhibits an increased probability of failure at some age, and

(2) A large portion of the population survives to that age, and

(3) A potential failure point does not exist or cannot be measured with accuracy and consistency.

c. Failure finding. Failure-finding tasks are applicable only if:

(1) They find a failure that is not evident to the operating crew during routine operations, and

(2) No other type of task is applicable and effective.

d. Servicing and lubrication tasks are assumed applicable by their very nature.

e. Block 12 – Applicable? Separates the tasks into two groups:

(1) Yes. The classified task satisfies all of the appropriate rules for applicability. The analyst marks “Y” in Block 12 and provides rationale for how each applicability rule is satisfied, or how the maintenance task was modified to make it applicable.

(2) No. The task, as written, does not satisfy all of the applicability rules for that type of task. Mark “N” in BLOCK 12 and evaluate whether the maintenance task can be modified to establish an applicable task. If so, list recommended improvements to change the task so it will satisfy the applicability rules. The analyst has several options to consider, including:

(a) Change task type (for example, time-directed to condition-directed);

(b) Modify the procedure or the scope of task procedures; and

(c) Change measurement of age (for example, operating hours vs. starts and stops)

If a task is modified to replace the non-applicable task, it must then be tested on its own and pass the rules of applicability for the modified task. If a task cannot be modified to satisfy the applicability criteria, explain why not, delete the task, and make the appropriate entries in blocks 15 and 16.

D.4.7 Step 5. Identify the failure consequence.

Determine the consequence of the failure by evaluating the impact on safety of personnel, loss of ability to comply with federal or state laws, and the ability of the ship to perform its mission (see 3.5). Failure consequences that are not identified as safety, regulatory, or mission will be classified as economic.

a. Block 13 – Consequence. Enter the consequence identified in step 5. When more than one consequence is identified, enter the highest level of concern (for example, if mission and safety are identified, enter safety).

D.4.8 Step 6. Is the existing maintenance task effective?

a. For failures involving personnel safety (life or limb) or law (for example, environmental regulations), a task is effective if and only if it reduces the probability of failure (P_f) to an acceptable level.

b. For failures involving operational performance (for example, ship's mission), a task is effective if it reduces the risk of failure (P_f x S_f) to an acceptable level.

c. For all other failures, a task is effective if the cost of the preventive maintenance is less than the cost of repair plus the cost of lost capability ($\$_{PM} < \$_R + \$_{LC}$).

d. Block 14 – Effective? Separates the tasks into two groups:

(1) Yes. The effectiveness rule for the task type is satisfied. The analyst marks "Y" in Block 14 and provides rationale for how the rule is satisfied.

(2) No. The effectiveness rule is not satisfied. Mark "N" in block 14. Review the improvement options, and evaluate whether the maintenance task can be modified to establish an effective task. If so, list recommended improvements to change the task so it will satisfy the effectiveness rule. The analyst has several options to consider including:

(a) Extend task periodicity;

(b) Sample vs. 100 percent inspection;

(c) Make task situational vice calendar-based scheduling;

(d) Modify task procedures

If a task is modified to replace the non-effective task, it must then be tested on its own and pass the rule of effectiveness for the modified task. If a task cannot be modified to satisfy the effectiveness criteria, explain why not, delete the task, and make the appropriate entries in blocks 15 and 16.

D.4.9 Step 7. Task improvement.

Even though a task may be applicable and effective, it may still be a candidate for improvement. For example, its effectiveness can possibly be increased by age-exploration as described in Appendix B. Age-exploration is the systematic process of increasing the time between preventive maintenance actions to achieve the optimal periodicity. The risk of failure is factored into the age-exploration process. Based upon as-found condition, we should increase the periodicity of the maintenance as far as risk will allow. When we have incrementally increased the periodicity to the point where we are seeing failures prior to the preventive maintenance interval, we then decrease the periodicity a notch to get back inside the failure point. Age-exploration is a very effective means to achieve the most cost-effective maintenance possible.

Applicable and effective tasks must also be evaluated for completeness and accuracy. Read through the procedure step by step and look for errors, inconsistency, or areas where misunderstanding could contribute to improper performance of the task. Some specific areas to consider are:

a. Are parameter specifications valid?

b. Are the correct rates listed?

c. Are the man-hours correct?

d. Are the correct tools, parts, materials, and test equipment listed? If the maintenance requirement is for a PMS MRC need to verify the correct SPMIG code is used.

e. Are hazardous materials properly identified including disposal information?

f. Block 15 – Change recommendation. Mark the appropriate choice based on the analysis.

g. Block 16 – Rationale and summary of recommended changes. As described in previous steps, this block is provided to record all rationale for applicable and effective tasks as well as any modifications or change recommendations. Changes to tasks must be described in sufficient detail to support development of a new or modified MIP and MRC.

D.4.10 Review and approval. Each Backfit RCM analysis shall be reviewed for completeness, accuracy, and adherence to the rules established in this appendix. Submit completed Backfit RCM analysis to the cognizant in-service engineering agent or other designated technical authority for review and approval.

a. Block 17 – ISE or TA Approval. Reserved for approval signature of the ISE or other designated technical authority listed in block 7.

b. Block 18 – Date. ISE or other designated technical authority signing for approval will enter the date of their signature.

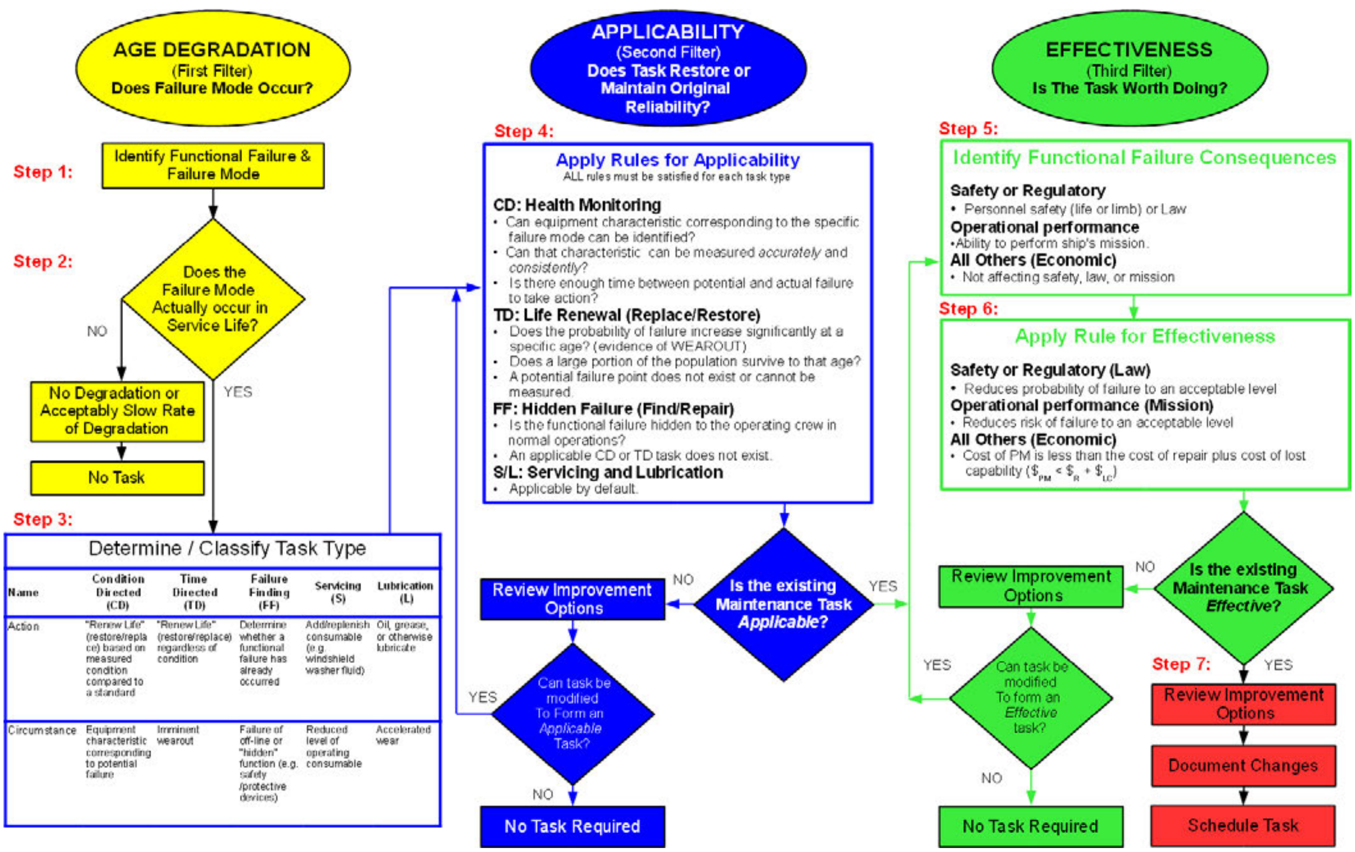

FIGURE D-1 Backfit RCM roadmap

Page of

1. CONTROL NUMBER	2. SYSTEM	3. TASK DESCRIPTION	4. PERIODICITY
5. PREPARED BY NAME: SIGN:	6. REVIEWED BY NAME: SIGN:	7. SYSTEM IN-SERVICE ENGINEER OR TECHNICAL AUTHORITY NAME: CONTACT:	
8. FUNCTIONAL FAILURE			10. AGE DEGREDATION? Y N
9. FAILURE MODE			11. TASK TYPE: CD TD FF S L
15. CHANGE RECOMMENDATION ☐ NO CHANGE ☐ CHANGE AGE MEASUREMENT ☐ CHANGE TASK PERIOD ( ) ☐ MODIFY TASK ☐ COMBINE WITH OTHER TASK(S) ☐ CHANGE MAINT LEVEL (O I D) ☐ ADD NEW TASK ☐ DELETE MAINTENANCE INDEX PAGE ☐ OTHER ☐ DELETE TASK			12. APPLICABLE? Y N 13. CONSEQUENCE: SAFETY REGULATORY MISSION ECONOMIC 14. EFFECTIVE? Y N
16. RATIONALE AND SUMMRY OF RECOMMENDED CHANGES			
17. ISE OR TA APPROVAL			18. DATE

BACKFIT DATA ANALYSIS FORM

FIGURE D-2. Backfit RCM analysis form.

WORDING, NUMBERING, CAPITALIZATION, AND PUNCTUATION

E.1 SCOPE

E.1.1 Scope. This appendix provides word, numeral, capitalization, and punctuation usage guidelines included in the Government Printing Office Style Manual which will be used unless modified herein. This appendix is a mandatory part of the standard. The information contained herein is intended for compliance.

E.2 WORD USAGE

E.2.1 Use of articles in technical writing.

a. System or equipment titles. An article is not used when system or equipment titles contain nomenclature AN, Mk, Mod, or unit numbers; for example, power is supplied to sonar set AN/BQR-2.

b. Deletion of articles. Deletion adds to brevity and impact and is desirable whenever it does not lead to confusion.

(1) Some modifiers also have verb forms. The meaning of such expressions depends upon the use of the articles, unless the rest of the sentence clarifies. The technical writer must keep the meaning clear.

This	**could mean this**	**or this**
Open door	Open the door	The open door
Lead wires	Lead the wires	The lead wires
Slack line	Slack the line	The slack line
Correct alignment	Correct the alignment	The correct alignment
Test oscilloscope	Test the oscilloscope	The test oscilloscope

(2) In most cases, the article "the" should be eliminated from the procedure.

Example A, with article: Remove the paper from the printer.
Preferred Example A: Remove paper from printer.

Example B, with article: Remove the printer from the mounting.
Preferred Example B: Remove printer from mounting.

E.2.2 Personal pronouns. The personal pronouns commonly used in procedures are "it" and "their". These can usually be omitted without changing the meaning of the sentence. When possible, they should be omitted.

E.2.3 Use of "that". It is not necessary to use "ensure that" in procedures. "Ensure" alone is sufficient.

a. This rule does not apply to other words, such as verify, observe, inform, advise, and so forth.

(1) If these words are followed by a clause, the word "that" should introduce the clause. For example:
Verify that the motor operates smoothly.
Ensure that the lamp is lit.

(2) If these words are followed by a noun (and modifiers), the word "that" may be omitted. For example:
Verify readings.
Observe standard safety precautions.

E.2.4 Choice of words. The following list contains words and expressions that are preferred because they are simple and short, or because they convey a precise meaning. The choice of the most appropriate word for an individual situation is left to the writer.

NOT RECOMMENDED:	PREFERRED:
All	this word may usually be omitted
as to	about, for, in, or
audible	heard
be sure	ensure
card, MRC card	MRC, MR card
carry out	perform or accomplish
check	this word should be used only when no more specific word is appropriate (test, verify, measure)
clean off	clean
clean with wire brush	wire-brush
cleaning solvent	solvent
commence	begin, start
connect together	connect
construct	build, make
consumption (n)	use (n)
confident	sure
create	make
depress	press
detect	find
diametrical	diametral
Engineering Officer	Engineer Officer
for a period of	for
flush out	flush
freeze up	freeze
give evidence of	show
is illuminated	is lit, lights
illustrate	show
in a clockwise (counterclockwise) direction	clockwise, counterclockwise
in case of	if
Initiate	start, begin
inspect that	inspect for
is capable of	can
manually operate	operate
observe for	inspect for
outside of	outside
physically inspect	inspect
prepare a mixture of	mix

NOT RECOMMENDED:	PREFERRED:
prior to	before
provided that	if
put together	assemble, reassemble
recheck	inspect
revolve	turn
run	operate
scale information	scale
should this condition exist	if this condition exists
such that	so that
take out	remove
take apart	disassemble, dismantle
turn on (motor)	start, restart (motor), energize
usage (n)	use (n)
utilize (v)	use (v)
visually inspect	inspect
warm up	warm
wipe off	remove

a. The word "secure" has more than 30 definitions. A more definite verb should be used if at all possible; for example, de-energize, fasten, stop, stow, tighten.

b. The word "type" is a useful but often an unnecessary word. For example, ball valve is preferred to ball-type valve. If the word "type" must be used, the word "of" would always follow it.

c. Preferred words and expressions:

NOT RECOMMENDED:	PREFERRED:
Operate the switch to OFF.	Set (position) switch to OFF.
Restore equipment to normal condition.	Return equipment to readiness condition.
Reinstall cover using new gasket.	Install new gasket and reinstall cover.
spots of rust	rust spots
The oil is free from foreign matter.	Oil is free of foreign matter.

E.2.5 Flaws and conventions. Because of similar spelling or meaning, certain words are often misused. This causes confusing statements and loss of clarity. The most commonly misused words, with definitions, are listed:

ABOUT	In the general area of.
APPROXIMATELY	Very close to - "Approximately" should be used with numbers.
ABOVE, BELOW	Indicate high or low. For example, units on a bulkhead are above or below each other, not over and under.
ACCEPT	To get or receive.
EXCEPT	To leave out, exclude.

AFFECT	Always a verb, means to act on; to impress; or to produce a change in.
EFFECT	As a noun, means result or consequence. As a verb, it means to bring about, to accomplish.
AMONG	Implies more than two objects.
BETWEEN	Implies only two objects.
AMOUNT	Refers to things measured in bulk, weight, or sums.
NUMBER	Refers to things that can be counted.
CITE	To use as an example, to quote (v).
SITE	Location (n), area.
CLOSE	Electrical contacts are closed.
SHUT	Mechanical devices are shut. For example, valves, doors, etc.
COMPARE, COMPARE TO	Used to point out likeness.
COMPARE WITH	Used to find likeness or difference.
CONTRAST	Always means to find difference.
CONTINUAL	Frequently or closely repeated, with little or no time in between.
CONTINUOUS	Without interruption, unbroken.
ASSURE	To promise, give assurance.
ENSURE	To make certain.
INSURE	To obtain indemnity against.
EQUIPMENT	The implements (as machinery or tools) used in an operation or activity. This meaning usually applies to everything needed, except personnel, for efficient operation or service. A collective noun meaning one or more pieces of equipment.
FARTHER	Expresses physical distance.
FURTHER	Expresses the sense of an idea.
FEWER	Refers only to numbers and things that are counted.
LESS	Refers only to amount or quantity of things measured.
GREATER	Refers to quantity.
LARGER	Refers to size.

THAT, WHICH — Both relative pronouns. "That" is always restrictive; "which" can be either restrictive or nonrestrictive. "That" refers to persons and things; "which" usually only refers to things. A good rule of thumb to remember is if the clause can be omitted without changing the meaning of the sentence, introduce the clause with which. If not, use that.

E.3 USE OF NUMERALS

E.3.1 Written or figures. The rule for use of numerals in technical writing is based on the general principle that the reader comprehends numerals expressed as figures more readily than the written expression of the number.

a. When writing the procedural portion of the MRC, numbers shall be expressed in arabic figures when stating time, measurement, or quantity of material.

b. Numeric expressions are written:

(1) At the beginning of a sentence.

(2) When two numbers are used in close proximity (one number is spelled out).

(3) When zero is used without associated figures.

E.3.2 Decimals. Use a zero before the decimal point when another figure does not precede the decimal even if there is a zero after the decimal point.

E.3.3 Commas. The comma is used in a number containing four or more digits. Exceptions occur in serial numbers, common and decimal fractions, military time, and kilocycles and meters of not more than four figures pertaining to radio; for example, 2300 hours, 1450 kilohertz, 1100 meters.

E.3.4 Aligning figures in columns.

a. When double rows of figures appear within a column, connected by a dash, plus, or minus sign, the word to or a similar connecting word; the dashes, signs, or words are aligned. Plus and minus signs at the left of figures are placed close to the figures regardless of alignment. For example:

40 to 600	+40.4
150 - 300	+98.1
4 to 10	-2.9

b. Decimal points are aligned except in columns containing numbers that refer to mixed units (inches and yards, grams and kilograms, pounds and ounces), in which case the column is aligned on the left. When a number in a column is a decimal, a zero is placed at the left of the decimal point. A zero alone in a decimal column is placed in the unit row and is not followed by a period.

In columns with mixed units and decimals of two or more places, no zero is added on the right. When a column has mixed units with single decimals only, a zero is supplied on the right. For example:

39.37 inches	0.7	0.7	1,000,000	0.7
2.6 yards	1.7	2.6	100,000	2.6
	3.5	3.5	1,000	3.5
28.35 grams	28.35	0	100	6.0
0.4356 kilogram	2.45	2.45	1	12.4
	1.4	0	0.1	132.0
2,204.6 pounds	12.8	8.6	0.001	18.2
32,478 ounces	3.9	12.22	0.0001	24.6

E.3.5 Fraction measurement.

a. If a fraction is used alone with a unit of measurement, a hyphen should connect them. For example, Oil is stored in 1/2-gallon cans.

b. If a compound number is used with a unit of measurement, the number itself must be hyphenated. Therefore, no hyphen can be used between the fraction and the unit of measurement. For example, Oil is stored in 1-1/2 gallon cans.

E.3.6 Numbers in parentheses. Do not write a figure in parentheses after writing out a number. This is proper only in legal or commercial writing.

E.3.7 Page identification.

a. When there is more than one page of an MRC, it shall be numbered in the center-bottom of each printed MRC page. For example, "Page 1 of 3". A single page MRC is numbered, "Page 1 of 1".

b. On the MIP, "Page 1 of 2" at the bottom-center of the first page and "Page 2 of 2" at the bottom of the second page would identify a two-page MIP. A single page MIP is numbered, "Page 1 of 1" at the bottom-center of the page.

E.4 CAPITALIZATION

E.4.1 Titles.

a. Capitalize the first letter of every word, except articles, short prepositions, and short conjunctions.

(1) Articles: a, an, the

(2) Short prepositions: at, by, if, in, of, for…

(3) Short conjunctions: and, but, or…

b. The words in the ship system, system, subsystem, and equipment blocks are titles. The maintenance requirement description sentences in the procedure block are titles.

c. Capitalize both parts of hyphenated words in titles; for example, High-Pressure Air System.

E.4.2 Itemized list capitalization.

a. These occur in the 'tools, parts, materials, test equipment' block of the MRC and sometimes as sub-steps in the procedure.

(1) Capitalize all letters of category headings.

(2) Capitalize the first letter of the first word in each item. For example:

TEST EQUIPMENT
1. [01529] Voltmeter, Differential AC/DC
2. [03212] High Voltage Test Kit

MATERIALS
1. [00878] Matting, Floor
2. [01144] Tag, Safety

E.4.3 Quoted expressions on tags. Capitalize the first letter of each word, except articles, short preposition, and short conjunctions; for example, "Do Not Operate", "Out of Service."

E.4.4 Notes, warnings, cautions. When used as a heading, capitalize each letter in the words: NOTE, WARNING, CAUTION. Capitalize the first letter in the sentence which follows one of these words.

E.4.5 Ships. Write the names of ships in all capital letters. Side letters belong in parentheses after the ship name; for example, USS HOLLAND (SS 1).

E.4.6 Abbreviations.

a. Ordinarily, abbreviations (see C.3.9) should not be capitalized. A few are capitalized, such as HP, LP, Mk, Mod, and No. Examples of those not capitalized are lb and ft.

b. If one letter of a normally lowercase abbreviation must be capitalized as part of a heading, capitalize all letters.

c. Capitalize each letter in NAVAIR, NAVSEA, NAVELEX, ORDALT, SHIPALT, and similarly authorized abbreviations.

E.4.7 Specific locations. When referring to a specific location, capitalize the first letter of each word. The use of an identifying number or letter with the name of the place makes it specific; for example:

a. Area 1, Area 2, Area 3…

b. Machine Shop No. 1, Panel No. 6.

E.4.8 Names of equipment parts (switches, handles, and so forth).

a. When the operator has to position an equipment part, the name of the part shall be exactly as imprinted on the equipment; for example:

(1) Set TURRET EMERG STOP switch to STOP.

(2) Set MAN-AUTO switch to AUTO.

b. Do not capitalize the name of a part that is not imprinted on the equipment; for example:

(1) Mount captain's firing switch.

(2) Turret officer's emergency switch.

c. If both the item name and the nomenclature appear in a sentence, capitalize the first letter of each word; for example, "Adjust Gun Sight Mk2".

d. If the equipment is written but is not accompanied by identifying number, Mark, Mod, do not capitalize the name; for example, "Adjust gun sight".

E.4.9 Missiles. Capitalize all letters in missile names; for example, TERRIER. Do not capitalize reference missiles; for example, ballistic missile.

E.4.10 Proper nouns now standard expressions. Some expressions contain words which were originally proper nouns, but which no longer have the meaning of the proper nouns. They have now, independent meanings; the proper nouns are no longer associated with the expressions. When we say arabic numerals, we think of the numbers rather than the country of Arabia. When we say plaster of paris, we think of the material, not the city of Paris. Do not capitalize such standard expressions which have come from proper nouns, if they no longer carry the weight of the proper noun.

E.4.11 Noun with number. A common noun used with a date, number, or letter to denote time or sequence does not form a proper name. Therefore, it is not capitalized; for example:

a. chart B

b. column 2

c. figure 7

d. page 2

e. table 4

f. step 2

E.5 PUNCTUATION

E.5.1 Period.

a. Sentences. Use a period at the end of a complete sentence. Do not use a period to end a group of words that is not a sentence.

b. Titles. Do not use a period at the end of a title, unless the title is a complete sentence.

c. Itemized lists. Do not use a period at the end of items under the 'tools, parts, materials, test equipment' block of the MRC.

d. Abbreviations. Do not use a period after abbreviations or MRCs, unless the abbreviation spells a word. For example, no period is required after qt, pt, gpd, vol, in-lb, and ft-lb. Periods are required after no. and fig.

e. References to procedural steps. References to procedural steps within an MRC shall be specific and shall be acceptable only in the following formats:

(1) Referencing one step: step 1.c.

(2) Referencing two steps: steps 1.c. and 1.d.

(3) Referencing three or more steps: step 1.c. through 1.e.(4).

E.5.2 Comma.

a. Use a comma after each member within a series of three or more words, phrases, letters, or figures used with and, or, or nor.

(1) Using three nouns: Inspect for rust, dirt, and old grease.

(2) Using three modifiers: Open inlet, outlet, and discharge valves.

(3) Using four verbs: Clean, inspect, lubricate, and test inter-compartment salvage valves.

b. Abbreviations. When transitional expressions such as i.e. and e.g. are used as introductory elements, they are always followed by commas.

c. Clarity. Use a comma where it is necessary to clarify and to prevent misreading of a sentence. For example, Avoid contact with, or inhalation of, cleaning solvents.

d. Adverbial clauses or phrases.

(1) When an adverbial clause comes after the main thought, when it is quite short, and when there is no danger that it can be misread, the comma may be omitted. For example, Replace piston valves if worn.

(2) An introductory adverbial phrase is usually set off from the rest of the sentence by commas. For example, If pointer rests to left of B marker, replace batteries.

(3) To avoid confusion, sometimes it is necessary to punctuate an adverbial phrase which comes after the main thought. For example, Replace valves, if worn, and gaskets, if deteriorated.

e. The use of the comma is often a matter of judgment. Commas should be used only for easy reading and clarity.

E.5.3 Colon.

a. The colon is used to introduce explanation, examples, quotations, and enumerations. A colon shall not be used after include, and are.

b. Titles. Use a colon after a marginal title when copy follows the title. For example:

(1) NOTE: Accomplish after 500 hours of operation.

(2) CAUTION: To prevent damage to a generator or regulator, do not operate engine below rated speed without setting regulator switch to off.

c. List. Use a colon after a word that formally introduces a list. For example:

(1) … at Control Panel Mk 362, position switches:

Nomenclature	Position
CONVENTIONAL WIRE GUIDE POWER	ON
FIRE CONTROL INDICATOR POWER	OFF
PRESET POWER	OFF

E.5.4 Semicolon.

a. Use the semicolon between two main clauses not linked by a coordinating conjunction (and, but, or, nor, for) or by the connections so and yet. For example, Be cautious of loose barbs when handling wire; wear gloves to prevent gouging hands.

b. A semicolon may be used to separate items in a series when the items contain internal commas. For example, Inspect equipment for pitting on outer surfaces; wear, especially on moving parts; and cracks around edges.

c. Do not use a semicolon between parts of unequal grammatical rank, such as a clause and a phrase or a main clause and a subordinate clause. For example, Construct two wave shaping networks; as shown in figure 1.

E.5.5 Apostrophe.

a. Plural abbreviations. The general rule is to use an ‘s to form the plural of abbreviations written in all capital letters. In technical writing, the accepted usage has allowed the apostrophe to be omitted when a lower case s is used; for example, MIPs and MRCs.

b. Possessives. The possessive case is not used in expressions in which one noun modifies another. For example, the motor frame or motor bearing.

E.5.6 Quotation marks (quoted expressions). Enclose statements on tags in quotation marks. For example, De-energize circuit and tag “DANGER – Do Not Operate”.

E.5.7 Underline. When emphasizing words, underline each word separately. Do not underline the entire expression with a solid line. For example, Do not disturb needle valve setting.

E.5.8 Parentheses.

a. Usage. Use parentheses to enclose words or expressions that are inserted for a comment, explanation, translation, or reference. For example, At UBWCS SWBD (Panel 123), position ZEROING switch to ZERO.

b. Punctuation.

(1) A reference in parentheses at the end of a sentence is placed before the period unless it is a complete sentence itself. For example:

Release four latches (two on each side).

Connect oscilloscope to test point TP-7 (see figure 1).

(2) If a sentence contains more than one parenthetic reference, the one at the end is placed before the period. For example, Remove hinge and O-ring (see figure 3) from mounting plate (see figure 2).

(3) Do not put a comma before a parenthesis.

c. Double parentheses. Do not use parentheses within parentheses. Use a pair of dashes for the outside parentheses; for example, A shipcheck – made in 2009 by NSWC PHD (Code 4400) – revealed minor technical errors.

E.5.9 Hyphen (compounding rules).

a. Use a hyphen:

(1) To join two or more words that serve as a single modifier before a noun; for example, fan-cooled area, shock-tested valves.

(2) In a long phrase in which several adjectives modify each other; for example, air-motor-driven pump.

(3) To hyphenate a combining verb form; for example, fan-cool area, shock-test valves.

(4) To avoid an awkward union of letters; for example, de-energize, anti-icing.

(5) When using a single letter to indicate shape, connect the letter to the word modified with a hyphen; for example, O-ring.

(6) To separate words in equipment titles on MRCs; for example, Indicator-Transmitter, not Indicator/Transmitter.

(7) Use a suspension hyphen in a series; for example, one or two-digit numbers.

(8) When dividing words at the end of a line, hyphenate words between syllables. Never divide a one-syllable word ending in “ed” such as sliced or mixed.

b. Do not use a hyphen:

(1) When the adjectives modify the noun independently (not forming a single modifying idea); for example, a volute centrifugal pump, an emergency power source.

(2) In a long phrase in which more than two adjectives independently modify the noun. Separate such phrases with commas; for example, multistate, mixed flow, volute centrifugal pump. (A comma is not necessary between the last two adjectives).

(3) When more than one word is modifying the same word; for example, salinity and temperature monitoring panels.

(4) When proper nouns are used as modifiers; for example, Atlantic Ocean salinity.

c. Double compound words. When using two long compound words in sequence, form the compound words, and separate them with a slash; for example, a control rod drives a bevel-gear-segment/bevel-gear-arrangement.

RCM RELATIONSHIP TO CBM+ TECHNOLOGY

F.1 SCOPE

F.1.1 Scope. This appendix provides the relationship between RCM analysis and CBM+ technologies. It depicts the best way to determine how to use CBM+ technologies to prevent or aid in the prevention of failures. It addresses how to use products of an RCM analysis to further analyze the incorporation of CBM+ technologies. This appendix is a mandatory part of the standard. The information contained herein is intended for compliance.

F.2 CBM+ BACKGROUND

According to DODI 4151.22, CBM+ implementation will enhance material availability and life cycle system readiness by reducing equipment failures during mission periods and identifying the best time to perform required maintenance, thereby increasing the operational assets.

The Chief of Naval Operations (CNO) has mandated that CBM practices be implemented in all Navy maintenance decisions involving ships, aircraft, and infrastructure in OPNAVINST 4790.16. The objective of CBM is that maintenance is performed based on objective evidence of need. RCM is the foundation for CBM; it is the process that is used to develop the maintenance tasks needed to implement CBM. According to OPNAVINST 4790.16, "All RCM methods shall continue to be used to determine the evidence to select the appropriate type of maintenance for Navy equipment and systems. RCM shall also be used to extend periodicity or eliminate unnecessary scheduled maintenance requirements based on operating experience, as applicable." Thus, the CBM program must, by OPNAV policy, begin with RCM.

OPNAVINST 4790.16 states that RCM provides the principles and rigorous methodology needed to select the appropriate type of maintenance. This statement is important because it instructs Navy on how CBM and RCM are related. CBM+ technology is wide-ranging, and constantly evolving. The RCM-developed PM requirements for a system or equipment are stable. What is needed is a way to link the maintenance tasks that RCM tells us to do with the technology available to assist in their performance, and help determine whether the technology is cost-effective.

F.3 CBM+ IMPLEMENTATION

The most cost-effective approach to CBM+ starts with the RCM analysis to determine the applicable and effective maintenance requirements for the system or equipment starting with the maintenance requirements index (MRI). The tasks shall be evaluated to determine whether a CBM+ technology is available to replace the task or tasks and then a business case analysis shall be performed to determine whether the technologies are cost effective. The more sophisticated the technology, the more expensive it may be. The increase in sophistication may also result in lower reliability. The reliability of the technology along with its costs are tradeoffs that shall be considered when evaluating CBM+ technology.

F.3.1 CBM+ technology decision logic tree. The analyst shall follow the steps in figure F-1 through the CBM technology selection process, staring with the initial RCM analysis through the technology acquisition process. The following steps correlate to the numbered boxes in the logic tree and shall be followed in sequence.

F.3.1.1 Step 1. The CBM+ selection logic shall start with a completed MRI for a system or equipment from a valid RCM analysis in accordance with this standard. The MRI shall contain all of the maintenance requirements, preventive and corrective, for the system or equipment. By using this process, the analyst can ensure the failure modes in question are likely to occur in service and are worth preventing.

F.3.1.2 Step 2. The analyst shall begin with a PM task for consideration in the CBM+ logic. PM tasks shall be condition-directed (CD), time-directed (TD) or failure-finding (FF). CD tasks lend themselves well to CBM+ technology because they are by nature driven by equipment condition related to a failure mode. TD tasks will benefit the most from CBM+ technology, if it can be effectively applied. This is because TD tasks are done on a fixed schedule regardless of equipment condition. Fixed schedules often result in lost serviceability when components are replaced when they still have useful life remaining. Transitioning to CBM+ from a TD task is then cost-effective. FF tasks are the most difficult to apply CBM+ technology. The goal of FF tasks is to find a hidden functional failure and they exist because no preventive task could be identified to prevent that hidden failure. The advantage that CBM+ technology presents is that the hidden failure inspection could be performed very frequently or near real-time, and possibly notify the operator of exactly when a hidden functional failure has occurred. An example of this is continuous built-in test functionality. This will minimize the loss of the hidden function.

F.3.1.3 Step 3. The analyst shall revisit and list the failure modes that the task is intended to prevent. A complete understanding of the failure mode(s) is essential in order to determine the potential of applying a CBM+ technology solution to its prevention.

F.3.1.4 Step 4. The analyst shall review the failure mode from Step 3 and identify if a CBM+ technology exists that can accurately and consistently detect the potential failure condition. The analyst shall answer the following questions:

a. Can the P_f point be discovered by technology that is either better or at least as good as the capability of the maintenance person? (The type of task identified in Step 2 leads into this step.)

b. Is there a technology that can replace that human inspector? (For CD tasks, there is an assumption that a human inspector can perform the task.)

c. Is there a P_f point that was not feasible for the human inspector to detect that is feasible for a CBM+ technology? (TD tasks generally do not use a human inspector; time is used as the trigger.)

For example, changing oil in an automobile. It is not feasible for the owner to inspect his motor oil and determine when to replace it – so it is done on the basis of mileage. However, if the engine is fitted with a wear-metal or contaminant detector in the oil system, or based on parametric sensor data and an algorithm, the technology could tell him when to change the oil. In this case, the TD oil change could be replaced with a CD oil change.

F.3.1.5 Step 5. Once it has been decided that there are CBM+ technologies available to support triggering of the maintenance procedure, they shall be listed and linked to the failure modes identified previously. The analyst shall identify all different types of CBM+ technologies available that can support the PM task before proceeding to step 6.

F.3.1.6 Step 6. The analyst shall validate and select which CBM+ technology is used. A previous example was given regarding changing of automobile motor oil based on a trigger by a wear-metal or contaminant detector in the oil system. Clearly this is more efficient with respect to getting maximum use of oil life, but when the high cost of installation of such a system is compared to the cost of TD oil and filter replacement (for example, every 3-5 thousand miles), the TD task is more cost effective and the CBM+ technology has a negative ROI. The analyst shall determine if there is more than one technology available to trigger the PM. The analyst shall evaluate each technology with respect to ROI. The ROI can be ranked and the highest return solution can be chosen, taking into account the reliability of each solution. The analyst shall consider the below factors when evaluating the ROI of the new technology:

a. Initial purchase cost of technology.

b. Infrastructure cost of the technology (equipment modification, networking of sensors, etc.).

c. Maintenance cost of the technology (for example, calibration and periodic testing).

d. Reliability of the technology.

The initial cost of the technology is of immediate concern and normally gets the most visibility. The analyst shall consider the cost of the infrastructure to support the technology, including infrastructure costs for power supplies, signal conditioning, cabling or wireless routers, panel displays, etc.

The capital cost in Step 6 shall include maintenance costs. If a technology must be tested, calibrated, or periodically adjusted, then the analyst shall evaluate whether ship's force has the capability and capacity to perform the maintenance. If ship's force cannot maintain the technology, then the cost of off ship maintenance shall be considered. The reliability of a technology is important because CBM+ technology is intended to replace the requirement for manual inspection or testing. If a CBM+ technology cannot be relied upon, then the manual method must remain.

F.3.2 Disposition of identified CBM+ technology. If any applicable CBM+ technology evaluated in Step 6 gets a "yes" answer with respect to ROI, then it is recommended that the technology be tested in a pilot or small scale application until a full production installation schedule is developed. If all identified CBM+ technologies get a "no" answer in Step 6, then the capital cost is currently too high and no identified technology is ready for Fleet application. Traditional methods of manual inspection or TD tasks must remain in place until such time as the life cycle cost of the technology pays for itself.

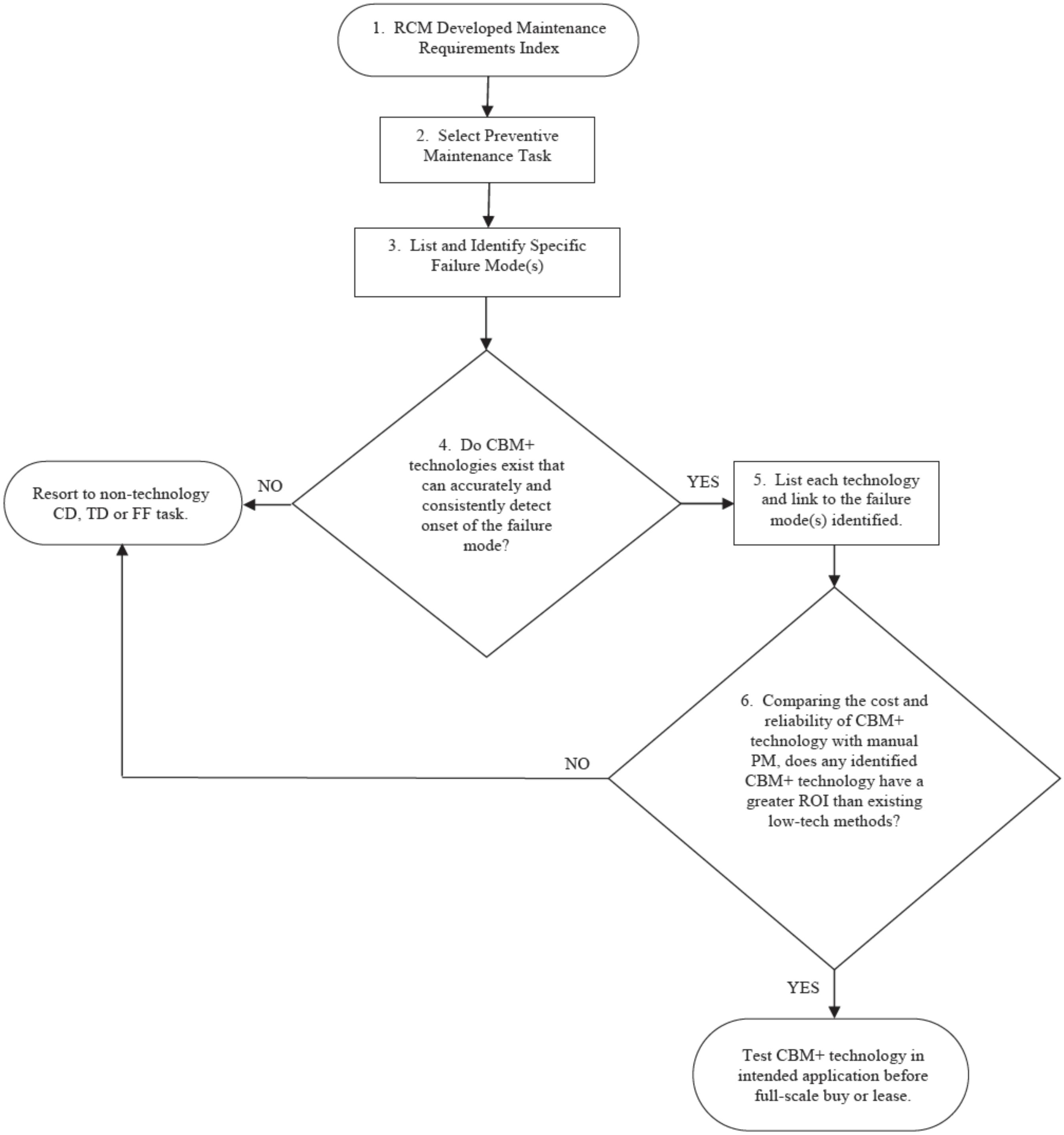

FIGURE F-1. CBM+ technology decision logic tree.

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Preparing activity:
Navy – SH
(Project SESS-2012-005)

Review activities:
Army – AC, AR, CR, MI, PT, TE, TM
Navy – AS, CG, CH, EC, MC, ND, OS, SA
Air Force – 01, 08, 10, 11, 13, 16, 19, 33, 94
DLA – CC, DH, SO
MISC – DC1, DC5, DI, MDA, MP, NRO, NS
OSD – DMS, HS, MA, SE

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