# CHAPTER 4

# COMBAT SYSTEMS, SUBSYSTEMS, AND MAINTENANCE

**LEARNING OBJECTIVES**

Upon completing this chapter, you should be able to do the following:

1. Identify the combat systems reference manuals for your class of ship in a combat systems environment.
2. Describe the subsystems that comprise shipboard combat systems.
3. Identify the objectives of the combat systems test and evaluation program.
4. Describe the functions of the ship's electronics readiness team.
5. Discuss integrated maintenance as it pertains to combat systems maintenance.
6. Identify maintenance testing required in a combat systems environment.
7. Describe the goals of fault isolation.

## INTRODUCTION

Compared to older combatant ships, today's combatants have more, and increasingly complex, electronics and weapons equipment and systems. Therefore, changes must be made to the traditional organization of division responsibilities. This means combining some of the responsibilities of the combat systems/weapons department.

In the past, technicians were only concerned with maintaining their assigned equipment so it would operate when it was needed. Now, under the combat systems concept, technicians must also ensure the accuracy of their equipment and system outputs into the combat system. Therefore, technicians must cross traditional boundaries and become familiar with the operation and capabilities of the overall system.

The outputs of combat systems equipment into the combat direction system (CDS) and weapons system control equipment must be accurate (within assigned standards): Without accurate signals and data, the ship may not be able to perform its combat mission.

Current practice has one officer, the combat systems/weapons officer, in charge of all weapons systems (all weapons and electronics subsystems) maintenance. This integrates the maintenance of all electronics and makes the ship more capable of fulfilling its mission.

In some configurations, it is possible that the engineering department will supply personnel for supporting systems, such as gyro distribution, cooling systems, primary power, and secondary power.

All subsystems of a combat system—weapons, search radar, communications, antisubmarine warfare, electronic warfare, and sonar—interface through the naval tactical data systerdcombat direction system (NTDS/CDS) subsystems. These collectively compose a single shipboard system.

All combat systems subsystems are very important to the overall readiness of combatants. As a senior technician and supervisor, you must work with your fellow combat systems technicians, supervisors, and operators to ensure a high state of combat systems readiness. Figure 4-1 illustrates the typical external components of a combat system.

## COMBAT SYSTEMS REFERENCE MANUALS

Two reference manuals are vital to the training of personnel in the operations of combat systems equipment aboard ships. They are a combat systems training requirements manual and a combat systems technical operations manual. Both of these manuals are generic, ship-class-specific publications that may be obtained aboard your particular ship.

### COMBAT SYSTEMS TRAINING REQUIREMENTS MANUAL

A combat systems training requirements manual (CSTRM) is developed for each class of ships in the force. It specifies the standards of technical and operational training expected for all operators and technicians of that ship class.

### COMBAT SYSTEMS TECHNICAL OPERATIONS MANUAL

Sophisticated combat systems integration is rapidly replacing the single-system operations found aboard older combatants. To help these ships adopt and maintain these technologically advanced systems, the Chief of Naval Operations (CNO) has directed that each ship within a ship class with tactical data systems and related equipments installed be provided with a combat systems technical operations manual (CSTOM).

Developed specifically for each ship of a class, the CSTOM contains the necessary technical data to provide the technicians with all aspects of systems capabilities, operations, and maintenance.

Specifically, the CSTOM contains and organizes the technical data that shipboard personnel need (1) to operate and maintain the integrated combat systems, (2) to maintain material and personnel readiness, and (3) to define significant capabilities and limitations of the combat system.

The CSTOM is also a reference for the following topics:

- The integration of systems and subsystems.
- The readiness requirements for operational and maintenance personnel.
- The establishment of the ship's electronic readiness team to maintain on-line combat systems readiness.
- The provision of text and graphic materials to be used for both classroom training and self- instruction. Pictorial diagrams, rather than conventional block diagrams, provide more-realistic training. Data are presented in levels ranging from elementary to detailed, allowing presentations to be made at the appropriate educational level.

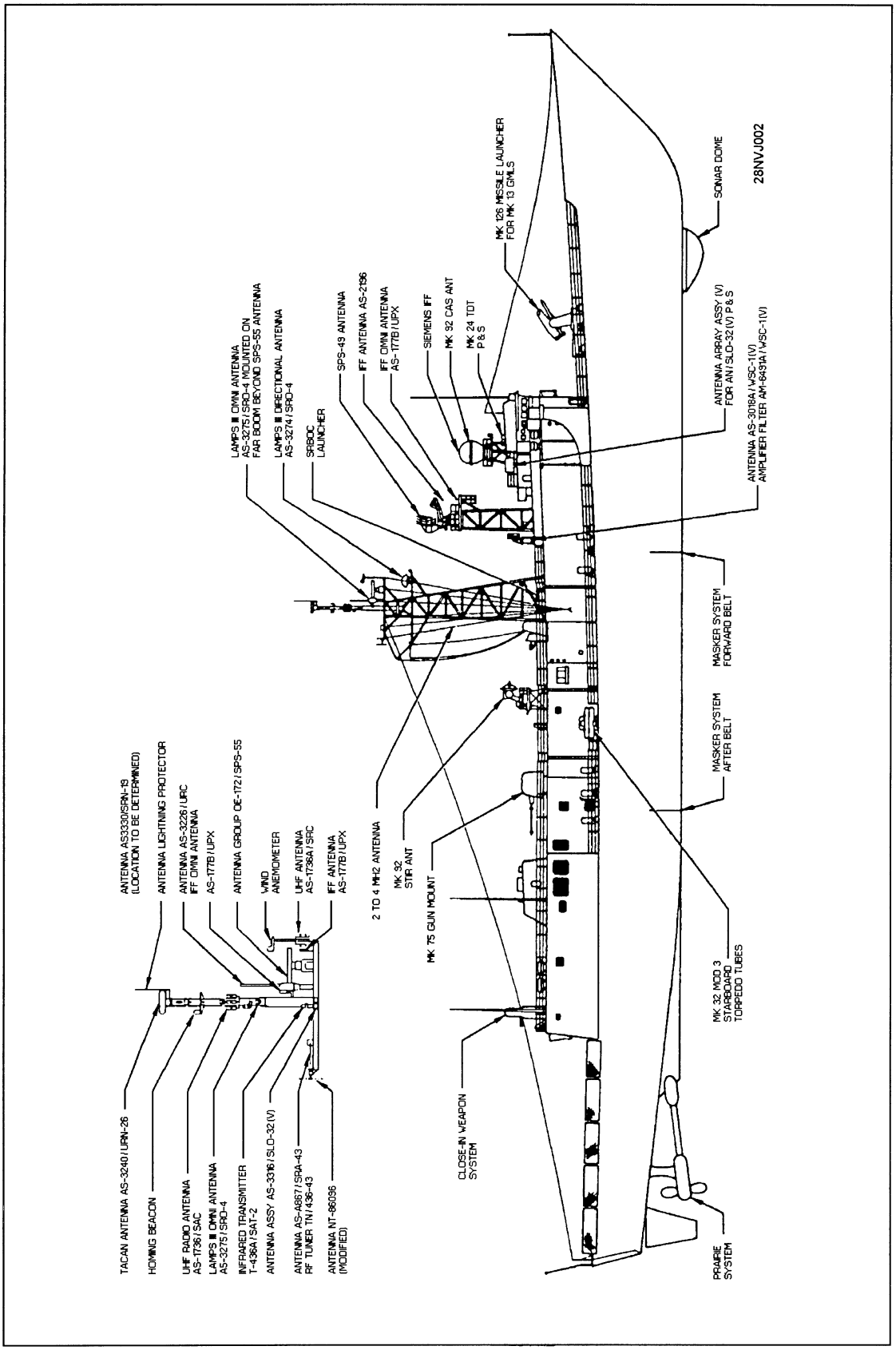



**Figure 4-1.—Typical external components of a combat system (FFG-7 class).**

## COMBAT SYSTEMS SUBSYSTEMS

Because many subsystems comprise an overall combat systems, it would be impractical to cover all the subsystems within this chapter. We will, therefore, discuss only a few of the major subsystems found aboard one ship class, the *Oliver Hazard Perry* (FFG-7).

All subsystems are very important to the readiness of the overall combat systems. Therefore, as a senior technician and supervisor, you must work with your fellow combat systems technicians, supervisors, and operators to ensure a high state of combat systems readiness.

## COMBAT DIRECTION SUBSYSTEM

The combat direction system (CDS) subsystem is a digital, computer-based, data-processing system that allows the crew to integrate, control, monitor, and make tactical use of the ship's weapons systems. It also allows the use of task force weapons against air, surface, and subsurface threats.

Sensor data from radar, sonar, countermeasures, and remote communications links are collected, correlated, and evaluated by the CDS operational program. The CDS program then develops and sends recommendations and alerts to the console operators to enable them to use their sensor and weapon resources efficiently.

The CDS is composed of three major equipment groups: (1) data processing, (2) data display, and (3) data communications.

## COUNTERMEASURES SUBSYSTEM

The countermeasures subsystem is a stand-alone subsystem that provides combat systems with detection, surveillance, identification, and engagement capabilities against threats the ship encounters during a mission.

This subsystem is divided into three functional groups: (1) electronic warfare support group, (2) acoustical countermeasures group, and (3) electronic attack group.

### Electronic Warfare Support Group

The electronic warfare support (ES) group supports actions taken to search for, intercept, locate, record, and analyze radiated electromagnetic energy in support of tactical operations. Thus, ES equipment provides a source of countermeasures information required for threat detection, warning, avoidance, and target acquisition.

The ES group also receives triggers from shipboard emitters and develops the blanking pulses required to prevent the emitters from interfering with operating countermeasures equipment.

The major components of the ES group are (1) the Electronic Countermeasures Set, AN/SLQ-32 (V)2; and (2) the Blanker-Video Mixer, AN/SLA-10B.

### Acoustical Countermeasures Group

The acoustical countermeasures (ACM) group provides deception devices designed to provide false or misleading acoustical targets for incoming acoustical homing torpedoes.

The major components of the ACM group are (1) the Torpedo Countermeasures Transmitting Set, AN/SLQ-25 (NIXIE); and (2) the Prairie/Masker System.

### Electronic Attack Group

The electronic attack (EA) group provides false or misleading targets for incoming missiles or other weapons. In conducting mission assignments, the ship uses decoy systems primarily as a defensive measure.

The major component of the EA group is the Super Rapid Bloom Offboard Chaff (SRBOC), Mk 36 Mod 1.

## CLOSE-IN WEAPONS SUBSYSTEM

The Close-In Weapons Subsystem (CIWS), Mk 15 Mod 1, provides the final defense against antiship cruise missiles (ASCMs) as part of the Navy's defense-in-depth concept. This subsystem engages and destroys ASCMs or aircraft that penetrate a ship's primary defense envelope. It also provides ASCM and antiair defense for ships operating in other than defense-in-depth situations and may be operated in either the antiair warfare (AAW) automatic or manual mode.

The CIWS is essentially a stand-alone weapons system consisting of (1) the Weapon Group, Mk 16 Mod 1; (2) the Remote Control Panel, Mk 340 Mod 1; and (3) the Local Control Panel, Mk 339 Mod 2.

## UNDERWATER WEAPONS SUBSYSTEM

The underwater weapons subsystem provides the combat systems with an engagement capability against subsurface threats.

The underwater weapons subsystem is composed of (1) the Sonar Set, AN/SQS-56; (2) the tactical towed array sonar (TACTAS); (3) the Torpedo Tubes, Mk 32 Mod 5; and (4) the Control Panel, Mk 309 Mod 0.

## LIGHT AIRBORNE MULTIPURPOSE SUBSYSTEM

The light airborne multipurpose system (LAMPS) is a computer-integrated, ship-helicopter subsystem that is capable of supporting both combat and noncombat missions. The primary combat missions are ASW and antiship surveillance and targeting (ASST). The secondary noncombat missions include search and rescue, medical evacuation, vertical replenishment, and utility operations.

The LAMPS consists primarily of the SH-60B Seahawk helicopter. This helicopter is an all-weather, airborne platform capable of carrying various detection devices, including a sonobuoy receiver-transmitter for transferring sonobuoy data to the ship.

Shipboard LAMPS equipment consists of (1) the Telemetric Data Receiving Set, AN/SKR-4A; and (2) the Sonar Signal Processing Set, AN/SSQ-28.

## MISSILE/GUN WEAPONS SUBSYSTEM

The missile/gun weapons subsystem enables the combat systems to deliver to a target an SM-1 missile warhead or a 76-mm gun projectile. This subsystem uses internally and externally generated raw data and processed data to provide the combat systems with weapons assignment, direction, and firing capability. This subsystem supports the combat system AAW, antisurface warfare (ASUW), and ASW missions.

## HARPOON MISSILE WEAPONS SUBSYSTEM

The Harpoon missile weapons subsystem provides a self-contained, surface-to-surface missile system capable of launching the Harpoon missile at over-the-horizon surface targets. The Harpoon missile weapons subsystem is the ship's primary surface-to-surface weapon. This subsystem relies on the weapons control processor (WCP) computer and other elements of the combat systems for target detection, threat evaluation, weapon pairing, and target data functions.

## SUPPORT SUBSYSTEM

The support subsystem is absolutely necessary to equipment operation. It consists of the following subsystems and equipments:

1. Dry air and nitrogen.

2. Liquid cooling and heating.

3. Ship power and distribution.

4. Ship parameters and distribution (own-ship heading, roll and pitch, own-ship speed and distance, and wind speed and direction).

5. Air conditioning and heating.

6. Interior communications.

## COMBAT SYSTEMS TEST AND EVALUATION PROGRAM

The Combat Systems Test and Evaluation Program (CSTEP) is a combination of special teams, tests, evaluations, publications, and reports used to promote the overall effectiveness and readiness of shipboard combat systems.

This program has three basic purposes:

1. To increase the priority and focus given to combat systems during overhauls and ship restricted availabilities (SRAs);

2. To increase the efficiency and effectiveness of combat systems evolutions that occur during a ship's life cycle schedule; and

3, To provide a procedure for the intermediate unit commander (IUC) to use periodically in monitoring and assessing the combat systems organization and readiness of individual units.

The overall goal of the program is to develop and maintain a high combat systems readiness in each unit in the force. Its specific objectives are as follows:

- Maintenance: To improve the combat systems maintenance condition of the force.

- Overhaul planning: To improve the planning process for the combat systems portion of overhauls and major ship restricted availabilities (SRAs).

- Overhaul. To improve the quality of work conducted on combat systems equipment, to increase the focus on combat systems integrated testing, and to ensure high levels of technical training during an overhaul or an SRA.

- Post-overhaul: To ensure maximum combat systems effectiveness immediately after overhaul by taking fill advantage of the basic and intermediate training associated with the overhaul or the SRA.

- Combat readiness: To maintain combat systems equipment readiness and training at a high level throughout the entire operational cycle of each unit in the force; to provide for efficient and effective management of combat-systems-related training, administrative, and readiness programs; and to provide a means to evaluate and report promptly a unit's combat systems readiness.

The CSTEP is composed of many elements, all of which are intended to increase combat systems readiness. Several of those programs are briefly discussed in this section. Table 4-1 shows a typical life cycle schedule of CSTEP key events.

Table 4-1.-Typical Life Cycle Schedule of Combat Systems Test and Evaluation Program Key Events

| EVENT | SCHEDULE |
|---|---|
| Pre-Overhaul Test & Inspection (POT&I), Phase I | Start ROH - 12 months |
| Pre-Work Definition Conference (Pre-WDC) Meeting | Start ROH - 7 months |
| Work Definition Conference (WDC) | Start ROH - 6 months |
| Forces Afloat Work Definition Conference (FAWDC) | Start ROH - 3 months |
| Immediate Unit Commander Pre-Overhaul Assessment (POA) | Start ROH - 4 weeks |
| Overhaul Activity Delivery ITP to Ship | Start ROH + 6 weeks |
| Ship Force/Overhaul Activity Complete ITP Review | Start ROH +25% |
| Combat Systems Coordinated Support Team (CSCST) | Start ROH + 60% |
| Commence Combat Systems Level Testing | Start ROH + 75% or<br>End - 12 weeks |
| Combat Systems Post-Overhaul Examination (CSPOE) | As soon as practicable after ROH, usually 2-3 weeks after |
| Training Readiness Evaluation (TRE) | End ROH + 5 weeks |
| Combat Systems Ships Qualification Trial (CSSQT) | End ROH + 9 weeks |
| Weapons System Accuracy Trial/Fleet Operational Readiness Accuracy Check (WSAT/FORAC) | End ROH + 14 weeks |
| DMSR | Before sailing for refresher training |
| Refresher Training (RFT) | End ROH + 15 weeks |
| Naval Gunfire Support (NGFS) Qualification | End ROH + 21 weeks |
| Combat Systems Operational Readiness Examination (CSORE), Phase I | 5 months before deployment * |
| CSORE, Phase II | 4 months before deployment |
| Combat Systems Readiness Review (CSSR) | Before deployment |
| CSORE, Phase III | 2 months before deployment |
| Deployment | End ROH + 40 weeks |
| Command Assessment of Readiness and Training (CART), Phase I | During deployment |
| CART, Phase II | End deployment + 5 weeks |
| Interim Refresher Training (IRFT) (as required) | End deployment + 12 weeks |
| NGFS Qualification | End deployment + 16 weeks |
| CSORE, Phase I | 5 months before deployment |
| CSORE, Phase II | 4 months before deployment |
| CSSR | Before deployment |
| CSORE, Phase III | 2 months before deployment |
| * New-construction ships will enter the CSTEP and the CSORE I before initial deployment. | |

## GROUP COMMANDER'S COMBAT SYSTEMS COORDINATION SUPPORT TEAM

The group commander's combat systems coordination support team (CSCST) assists in monitoring and assessing an individual unit's combat systems organization and readiness during all combat systems readiness evolutions. During these evolutions, the CSCST conducts ship visits to evaluate and help develop shipboard programs to improve combat systems readiness. Until permanent CSCST detachments are formed in individual home ports, group commanders form CSCSTs from assets within the group and the ship's home port.

Specifically, the CSCST takes the following actions:

- Reviews combat systems administrative support (i.e., technical manuals, CSTOMs, consolidated ship/station allowance list [COSAL], planned maintenance system [PMS], general-purpose electronic test equipment [GPETE]), assesses progress during overhauls and ship restricted availabilities, conducts reviews of the combat systems integrated test plans (CSITPs), and supports CSPOE/CSORE.

- Evaluates and, when required, conducts technical training to improve the ship's force ability to light-off, test, operate, and maintain combat systems equipment.

- Evaluates the effectiveness of the ship's electronic readiness team.

- Assists in conducting the following CSTEP events:

  — combat systems pre-overhaul assessment

  — combat systems post-overhaul examination

  — combat systems operational readiness examination (phases I and II)

## NAVSEACEN COMBAT SYSTEMS READINESS ASSISTANCE

Personnel from the NAVSEACEN provide engineering technical support and material services to forces afloat. They assist in conducting combat systems readiness reviews (CSRRs) and provide technical assistance for gun/missile/ASW battery and gunfire control/missile fire control/ASW fire control. These reviews are not the same as the technical assistance for repairs provided by fleet technical support centers (FTSCs). Instead, they provide assistance necessary to further the "self-reliance" of the ship's force in improving the operational readiness of installed ordnance.

## COMBAT SYSTEMS READINESS REVIEW

The comprehensive combat systems readiness review (CSRR) helps the ship's force to achieve a high state of combat systems readiness for deployment. Implicit in this goal are the following objectives:

- To assess the readiness of the ship's combat systems materiel and personnel and to report the status to appropriate seniors

- To help the ship's force and the IUCs correct material problems

- To provide on-the-job (OJT) training for the ship's force personnel and to improve the ship's self-sufficiency

## ORDNANCE SPECIAL ASSISTANCE TEAM

The ordnance special assistance team (ORDSAT) consists of several technicians, both military and civilian, highly trained in various fire-control systems. The team's primary purpose is to instruct the ship's force in how to maintain its own equipment, thereby

improving its battery system as a whole. Ordnance equipment includes gun battery, gunfire control, guided-missile fire-control, and underwater battery fire-control systems.

### COMBAT SYSTEMS OPERATIONAL READINESS EXAMINATION

The combat systems operational readiness examination (CSORE) is an evaluation conducted in three phases by the ship's IUC to determine the material readiness, personnel training level, and logistics support of the installed combat systems.

### COMBAT SYSTEMS POST-OVERHAUL EXAMINATION

The combat systems post-overhaul examination (CSPOE) is an evaluation of the combat systems readiness and training of the ship. It provides prerequisite testing and preparation for CSSQTs, WSATs, and RFT; evaluates equipment readiness and the ability of the ship's force to light-off, operate, and maintain equipment; and assesses the combat systems technical training.

### COMBAT SYSTEMS SHIP QUALIFICATION TRIALS

The combat systems ship qualification trials (CSSQTs) is a series of comprehensive tests and trials designed to show that the equipment and systems included in the CSSQT program meet combat systems requirements. It also provides training and familiarization to ship personnel in maintaining and operating installed equipment, identifies design problems, and determines deficiencies in support elements (i.e., documentation, logistics, test equipment, or training).

### OVERALL COMBAT SYSTEMS OPERABILITY TEST

The overall combat systems operability test (OCSOT) is a level-1 PMS test designed to provide the commanding officer with an operational assessment of the total combat systems.

### COMBAT SYSTEMS IMPROVEMENT PROGRAM ADVISORIES

The numbered combat systems improvement program (CSIP) advisories are used by the type commander (TYCOM) to pass on to units lessons learned, recommendations, and specific guidance on combat systems requirements.

### COMBAT SYSTEMS INTEGRATED TEST PLAN

The combat systems integrated test plan (CSITP) consists of detailed procedures for conducting all combat system tests through the systems level during overhaul. For further information on the CSITP, refer to *Combat Systems Test and Certifiction Manual*, NAVSEA T9073-AB-TRQ-010.

### COMBAT SYSTEMS TEST COORDINATOR

The combat systems test coordinator (CSTC) is the ship's representative to the combat systems test task group. The CSTC is responsible for coordinating all testing with the shipyard and for ensuring that all testing is completed and involves the full ship's force.

### SHIP'S ELECTRONICS READINESS TEAM

The CSTOM assigns to the ship's electronics readiness team (SERT) the responsibility for maintaining on-line combat systems readiness. Administratively, the SERT reports to the systems testing officer (STO), who, in turn, reports to the combat systems officer (CSO)/weapons officer.

If your ship has a SERT, the discussion in this subsection should help you understand its purpose. If your ship does not yet have a SERT, you may wish to use some of the SERT's procedures within your area of responsibility. See figure 4-2.

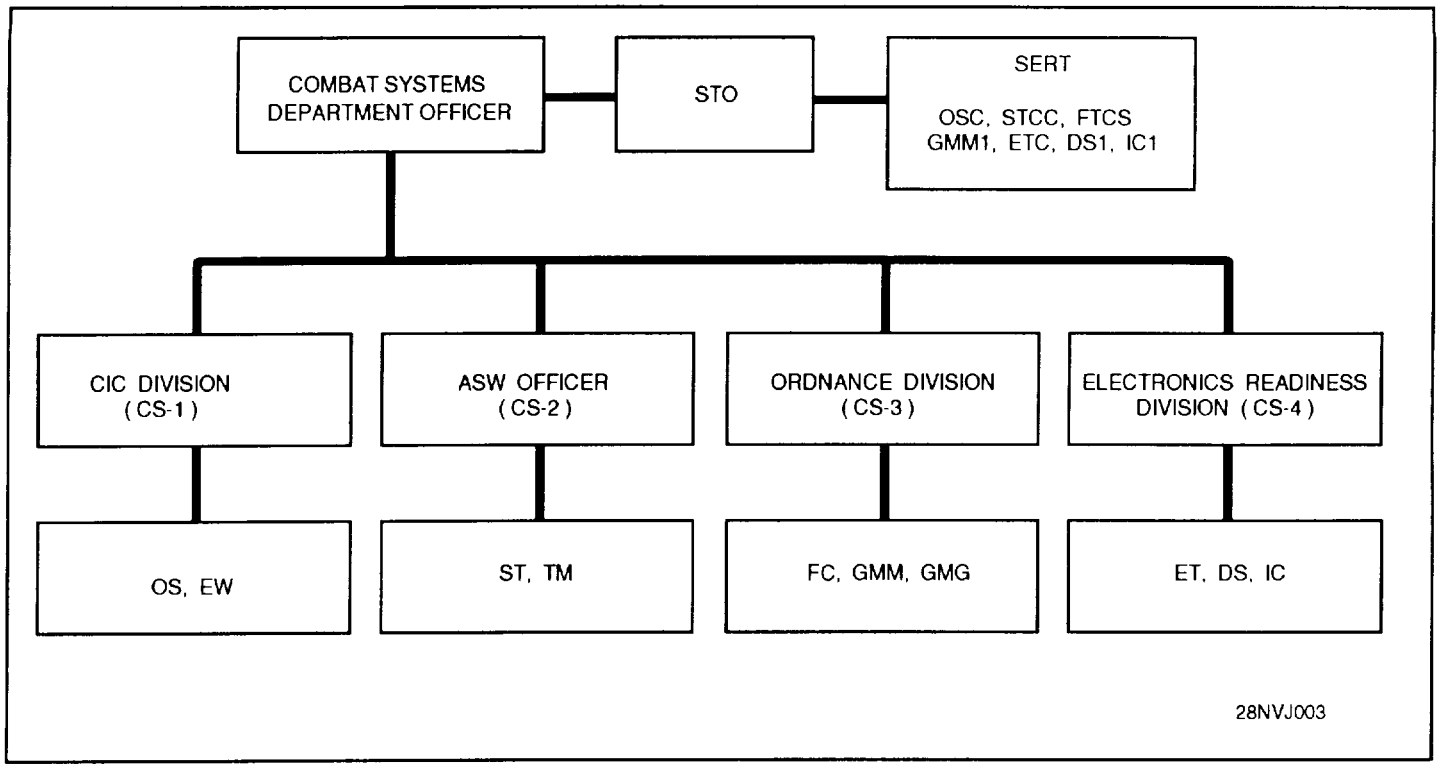



**Figure 4-2.-Typical combat systems/weapons department organization.**

### SERT Training

Using the CSTOM as the basic reference, the SERT is trained as a unit in combat systems operations, preventive and corrective maintenance, maintenance management, and training.

The SERT members should have knowledge in the following areas, either by previous formal training or by a rigorous shipboard training program:

- PMS philosophy.
- PMS scheduled and corrective maintenance.
- Planned maintenance during overhaul.
- Maintenance data system.
- Combat systems, subsystems, and equipment operation.
- Ship alteration, ordnance alteration, and field change configuration levels.
- Combat systems, subsystems, and equipment maintenance and scheduling.
- Ordnance pamphlets and data, and NAVSEA manuals.
- Combat systems, subsystems, and equipment tests.
- Logistics support.

Members of the SERT are senior petty officers with extensive experience in subsystems and equipment maintenance. Each must be an expert on at least one subsystem. Since the SERT is an official part of the ship's organization, the duties of its members are primary, not collateral. Figure 4-3 shows where the SERT fits into the ship's organization.

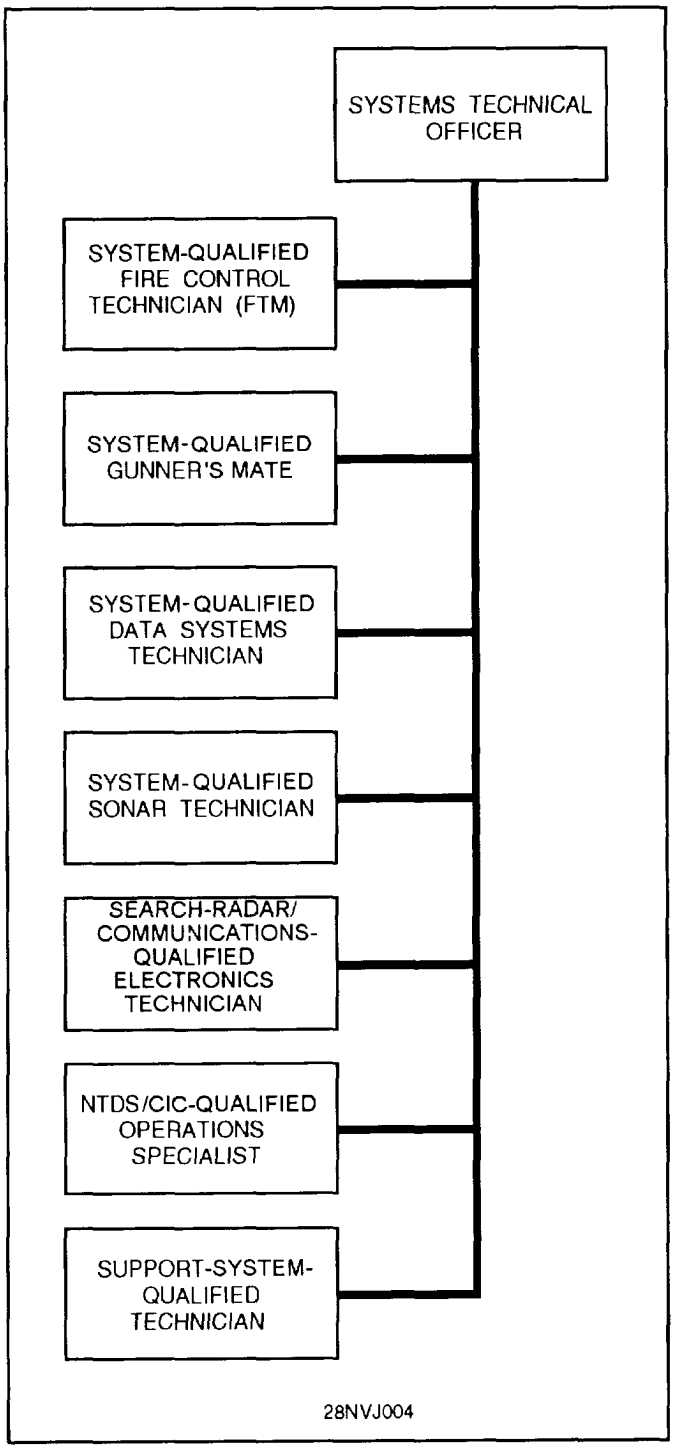



**Figure 4-3.-Typical ship's electronics readiness team organization.**

## SERT Operations

For the SERT to coordinate preventive and corrective maintenance efforts effectively, there must be extensive coordination and cooperation among the major branches of the combat systems/weapons department. The SERT members should have direct access to the leading petty officers of each subsystem group within the combat systems/weapons department.

Additionally, because combat systems do not include all maintenance and operational departments of the ship and because combat systems cannot operate without the support of other departments, all departments should be involved in implementing a system-level maintenance program. Both officers and enlisted personnel should participate in the scheduling process for the plan.

For the SERT to be held responsible for combat systems readiness, it must have clearly defined responsibilities and authority. This is best done by a specific shipboard instruction. The SERT's authority should be in the area of organization, as well as in materiel and personnel readiness.

The knowledge that SERT personnel have must not be confined to a particular subsystem if the organization is to function properly during condition III and in port.

For all personnel to quickly understand combat systems availability during conditions I and III, and in port, the SERT should establish the following three lines of communications:

1. Condition I: The STO should be assigned a general quarters station in the combat information center (CIC). He should be able to inform the tactical control officer (TCO) of the present and changing status of combat systems availability on a threat basis. The rest of the SERT members should be assigned as roving evaluators for subsystems with which they are most familiar. If possible, the duties of the roving evaluators should be rotated to ensure that SERT members become familiar with all areas without affecting the overall operation of the combat systems.

2. Condition III: At least one SERT member should be on watch in the CIC, with the responsibility of reporting combat systems status to the tactical action officer (TAO). The remaining SERT

members should perform their regular duties of testing, instructing, and evaluating maintenance activities.

3. In port: At least one SERT member should be assigned to each duty section so that the command duty officer (CDO) will know the actual systems status at all times.

**SERT Responsibilities**

Responsibilities of the SERT are broadly defined as maintenance management, readiness assessment, and operational training guidance required to ensure high-level combat systems readiness.

Specific responsibilities of SERT include the following actions:

- Integrating and managing PMS for the combat systems.
- Determining mission-related materiel readiness.
- Managing the corrective maintenance effort for the combat systems, including fault isolation, and data collection and analysis.
- Monitoring operational performance during condition watch exercises and ship or fleet operational exercises.
- Evaluating both materiel and operational readiness of the combat systems, and providing internal or external reports as necessary.

**SERT PMS Management**

The SERT PMS management includes supervision of actual maintenance actions and all other efforts required to plan and support maintenance events. Therefore, the management task involves controlling all combat system PMS activities, including PMS tasks for the combat systems, subsystems, and equipments. The SERT provides the foundation for maintenance through proper planning and execution.

Certain PMS procedures at the combat systems level are more oriented toward operator proficiency, with summary observation of combat systems performance. The management guidance in the PMS manual and the cycle and quarterly schedules is primarily equipment- and department-oriented. This guidance provides minimum maintenance requirements for the subsystems and equipments covered under PMS. The SERT must operate within such factors as the interdependence of equipments and subsystems in the overall combat systems, the variations of available manpower, and the dedication of subsystems to operations during conditions I and III.

The scheduling and performance of PMS (supported by documentation and maintenance training) leads to fault detection, which provides a basis for readiness assessment. Maintenance management ensures that detected faults are isolated and followed by corrective action. Effective corrective maintenance includes logistics control and the determination of how important each corrective maintenance requirement is, based on parts availability and readiness assessment.

Follow-up actions, including verification or retesting, and complete shipboard and maintenance data collection reporting are essential to an effective PMS program.

**SERT Materiel Readiness Assessment**

The SERT materiel readiness assessment is directed toward four major missions: AAW, ASW, ASUW, and amphibious warfare (AMW). Materiel readiness assessment involves performing tests and operational checks on the subsystems to identify equipment that is either degraded or nonoperational. The results of the tests and operational checks are then used to determine how well the subsystems can perform their mission requirements.

Readiness assessment is probably the most difficult task facing the SERT because it requires the ability to provide an up-to-the-minute status of the capabilities and limitations of the combat systems. It also requires the ability to recommend alternate combinations of equipment to meet mission needs.

The SERT must know the results of all tests and, in addition, the minute-to-minute availability of the combat systems, its subsystems, equipments, and all support functions, such as primary power, chilled water, dry air, and sound-powered telephones.

Although all equipment problems are important, the existing tactical environment can modify their impact on a mission capability. For example, losing the moving target indicator capability can be more important when the ship operates near land masses than when it operates in the open sea.

Materiel readiness assessment should be approached from the functional readiness aspect, rather than the equipment up-or-down-status aspect for the following reasons:

- Complex, multifunction electronic equipment is seldom completely down and less frequently completely up. Normally, one or more functions are in various states of degradation.

- The impact of a fictional fault maybe different for the capability of each mission.

- The complex design of the combat systems includes some fictional redundancy.

- The test results and operational fault directories relate problems to their effect on system functions rather than to the basic operation of the affected equipment.

Readiness assessment uses two basic types of techniques: quantitative and qualitative.

- Quanitative techniques involve the extensive use of mathematics and reports based on graphs and numbers. Past shipboard experience has shown that without computer support, quantitative assessment is not easily managed. Its numerical reporting lacks meaning or requires extensive explanation.

- Qualitative assessment (an application of engineering analysis) is based on system knowledge, experience, and judgment. It is usually a verbal report. These assessments depend on the personal experience level of the users. Therefore, written guidance and report forms are required. The impact of no-go conditions, revealed by PMS results, must be determined for each mission capability.

After an assessment is made, each major function is assigned one of the following four readiness criteria:

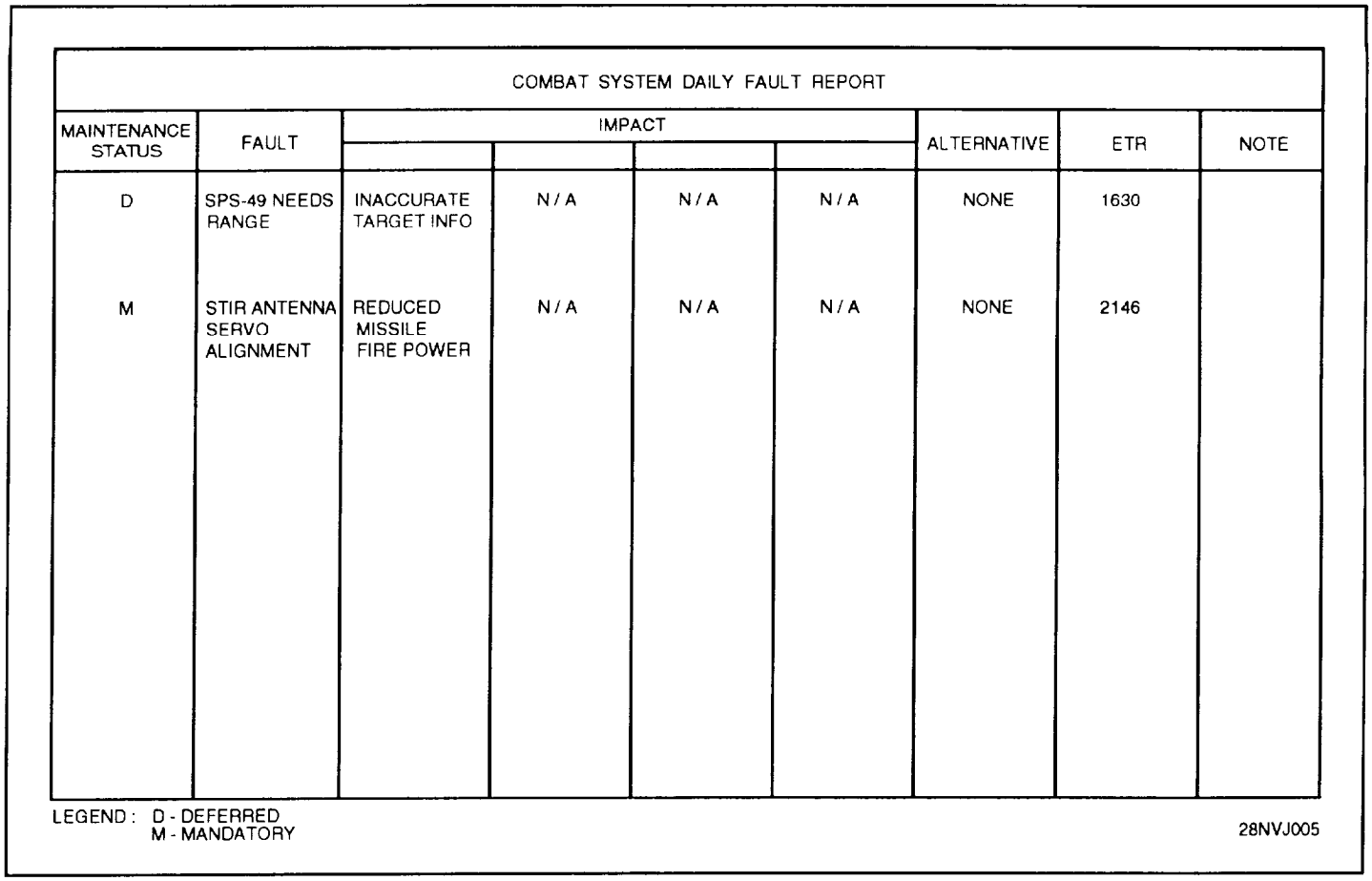
1. Fully combat-readv status: All equipments associated with a specific function are in the highest state of readiness with respect to that function.

2. Substantially combat-ready: Although all the equipments may not be fully operational, redundancy permits the mission to be continued, resulting in a high probability of success.

3. Marginally combat-ready: A function may be performed, but with a much-reduced probability of success.

4. Not combat-ready: The equipment has a complete loss of function.

These readiness criteria provide the basis for a summary report of readiness. A combat systems daily fault report should be submitted, listing the subfunction faults of the day, their individual impact, any alternative recommendations, and the expected time of repair. See figure 4-4 for an example of a daily fault report.



COMBAT SYSTEM DAILY FAULT REPORT

| MAINTENANCE STATUS | FAULT | IMPACT | | | | ALTERNATIVE | ETR | NOTE |
|---|---|---|---|---|---|---|---|---|
| D | SPS-49 NEEDS RANGE | INACCURATE TARGET INFO | N/A | N/A | N/A | NONE | 1630 | |
| M | STIR ANTENNA SERVO ALIGNMENT | REDUCED MISSILE FIRE POWER | N/A | N/A | N/A | NONE | 2146 | |

LEGEND: D - DEFERRED
M - MANDATORY

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**Figure 4-4.-Example of a combat systems daily fault report.**

Materiel readiness does not end with the successful completion of tests and scheduled maintenance. In addition to testing, other actions (such as visual inspection for cleanliness, corrective maintenance, quality control, and complete integrity) are a necessary part of SERT responsibilities.

Also, requesting the commanding officer to conduct materiel inspections, assigning SERT personnel to inspection teams, and conducting random equipment inspections without prior notice may provide excellent results, Such inspections should be for electronic and mechanical materiel readiness and preservation. The SERT representatives should also provide results of such inspections to appropriate authorities and provide follow-up inspections to ensure that corrective action is taken.

### SERT Corrective Maintenance Management

SERT corrective maintenance consists of two basic categories: fault isolation and corrective maintenance.

- The SERT is responsible for directing fault isolation at the combat systems level, managing corrective maintenance at all combat subsystems levels, and coordinating corrective maintenance in related support subsystems.

- The SERT responsibility for corrective maintenance also includes coordinating fault-isolation efforts and evaluating the impact of faults to determine the priority of each corrective maintenance requirement.

Two other SERT responsibilities are (1) follow-up action of verification or retesting, and (2) complete shipboard and maintenance data collection subsystems reporting. Effective corrective maintenance management first requires the consideration of combat systems readiness, then efficient use of manpower. These factors closely relate to the ship's employment and the tactical environment.

There will be times when more corrective maintenance requirements exist than can be simultaneously handled by the available manpower. In addition, sometimes parallel faults exist that require the same personnel or the same system setup for fault isolation. When these conditions occur, the setting of repair priorities is based on management's requirements for readiness and available manpower to make the repairs.

As the SERT collects and evaluates PMS results, it should continually base its recommendations for correcting faults on the tactical situation, complexity of fault isolation, and available manpower. Some faults may be designated for correction; others may be deferred. However, deferred faults, if left to accumulate, tend to degrade overall systems readiness. Therefore, as soon as the situation permits, deferred faults should be repaired.

Faults detected within combat systems must be isolated to a subunit that can be replaced or repaired or to an alignment that can be made before actual corrective action can be taken. Therefore, technicians must have a thorough knowledge of the systems and access to complete systems and equipment documentation.

Most subsystems and equipment maintenance publications provide fault-isolation support in one or two formats. The first format consists of symptoms presented in preselected, logical steps and in reference tables, a logic chart, or logic diagram format. The second format consists of flow diagrams and relay ladders. The CSTOM provides amplifying information on fault isolation.

After a repair priority has been set and the faults isolated, the managers of corrective maintenance must ensure that corrective action is taken, verification is made by retest, and required reports are completed. Since some faults tend to be repetitive, the SERT should keep records of fault symptoms, identification, and corrective measures.

**SERT Monitoring**

The SERT responsibility for operational training is vital since overall readiness assurance is a function of operational readiness (personnel proficiency) and materiel readiness. The goal of operational readiness is to achieve maximum combat systems capability for each mission under constantly changing conditions of materiel readiness. The measurement of personnel readiness is based on the three following techniques:

1. PMS tests: In each case, the hardware must be operating properly. Otherwise, the capabilities of the personnel cannot be determined accurately.

2. Simulators or computer programs: The video signal simulators with computer programs provide a means to assess the skill of the console operator. However, the computer programs are limited in assessing the capabilities of combat systems operators.

3. Monitoring of ship or fleet exercises: one way to evaluate the capability of all combat systems personnel is to actually monitor ship or fleet exercises. These exercises include:

- Electronic warfare exercises.
- Gunnery exercises (antiair [AA], surface, and shore).
- Missile exercises (AA and surface.)
- CIC exercises (aircraft, tracking and control).
- Antiship cruise missile exercises.
- ASW exercises.

When the SERT finds personnel deficiencies, it must provide operational training and guidance.

Since the SERT has the knowledge and training capability, it is uniquely qualified to assist the ship's training officer in identifying the topics and content of necessary training for both officers and enlisted personnel.

As an FC supervisor, you will periodically evaluate the operational readiness of your personnel. You should ensure that they are familiar with the following topics:

- Intended purpose of all switches, indicators, controls, and the impact each has on other subsystems or combat systems equipments.
- Communications links available at the station and with the other stations.
- Compliance with specified communications disciplines.
- Knowledge that the lack of communications discipline is an internal hazard to the combat systems or to the ship.

**SERT Test Selection and Scheduling**

The integrated approach to testing is based on defining all functional test requirements and subjecting them to a critical examination. The examination involves an engineering analysis in which each function, parameter, and characteristic is examined for (1) its importance to mission or mode performance, (2) its reliability based on the circuit elements that affect the function, and (3) its expected mean time between failures.

This approach places a test periodicity (daily, weekly, monthly, quarterly, semiannually, annually, and cyclically) on the functions. Critical functions are assigned a high periodicity, regardless of reliability; while less critical functions may be assigned a lower periodicity based on their reliability.

Related functions are grouped by periodicity and functional interdependency so that they can be tested during appropriate periods. The tactical situation governs how and when maintenance is scheduled.

Scheduling is a critical element of preventive maintenance management and requires a thorough knowledge of the intent and conditions of each maintenance requirement card (MRC).

Important conditions include

- in-port and at-sea requirements,
- outside service requirements,
- navigational support requirements,
- combat systems operational usage,
- ship control requirements,
- emission control conditions,
- computer program requirements,
- subsystems interdependency,
- impact on computer program capability,
- adverse weather conditions,
- time requirements, and
- manpower requirements.

From these conditions, the quarterly schedule can be developed, based on the ship's employment schedule. Heavy maintenance is usually scheduled during in-port periods and independent ship exercises during nonthreat conditions (particularly for those procedures requiring long periods of operational equipment downtime).

If the employment schedule changes, the PMS schedule may require modification. Daily and weekly schedules are based on the ship's readiness condition and operational situation. Subsystem interdependence and manpower usage are also critical in scheduling.

Preventive maintenance management includes the following requirements:

- Ensuring that events take place as scheduled
- Coordinating manning and equipment availability for interdependent testing
- Providing adequate safety measures
- Ensuring the availability of required supporting systems
- Coordinating the actions of command and tactical operation personnel
- Ensuring fault isolation and corrective maintenance follow-up
- Ensuring the completion of required reports

The ship's CSTOM contains readiness assessment and fault-isolation diagrams that (1) indicate the test that requires the fewest ship resources, (2) verifies each combat systems interface function, and (3) aids the SERT in preventive maintenance management.

**SERT Readiness Assessment Reporting**

After readiness assessment is completed, the readiness status must be reported in a form that is brief and easily understood and that presents a clear picture of the combat systems effectiveness. This is done most effectively by addressing the status of the combat systems equipment as it relates to a mission capability. This summary report also provides a brief description of the effect each division's group has on the overall combat readiness of the ship.

Supporting information on specific subfunction faults related to the summary report sample maybe provided in a combat systems daily fault report form. Figure 4-4 shows a sample method of presenting daily fault information. The SERT should develop report forms similar to that shown in figure 4-4 to fit the ship's requirements. The combat systems daily fault report is the responsibility of the SERT and should provide enough information for the CSO to develop the mission summary reports.

The SERT must evaluate, monitor, and report systems status during competitive and fleet exercises. This includes organizing and instructing observers, preparing recording forms, defining data requirements, collecting and evaluating data, and preparing a composite internal report. These reports should be limited to an evaluation of combat systems materiel and personnel readiness during the exercise.

**SERT Alignment Logs**

The SERT is responsible, during PMS activities and exercises, for determining the mechanical and electrical alignment of interrelated combat systems functions. The SERT must also assess the impact of a misalignment on the mission.

When SERT members brief subsystems and equipment personnel before an exercise or mission, they must emphasize the need for caution when making adjustments to equipment subsystems that may, in turn, affect the total combat systems alignment.

Alignment tests and efforts to reestablish reference standards are complex and time-consuming. They frequently require shore facilities, ideal environmental conditions, and extensive data collection. Technicians should avoid making realignments that, because of incomplete or inaccurate reference data, result in inefficient use of manpower and resources.

Experience has shown that unnecessary alignment efforts can be avoided if reference data are kept current, are accessible, and can be interpreted by all team members. Therefore, a combat systems alignment smooth log (if not already in effect) must be maintained and kept current and accurate.

A total combat systems alignment manual for the class of ship (with combat system) should be available (separate from the CSTOM). The manual should explain the purpose of total combat systems alignment, provide management data needed for the analysis and troubleshooting of alignment problems, and provide step-by-step procedures needed for combat systems alignment.

## INTEGRATED MAINTENANCE

Combat systems integrated maintenance is based on a comprehensive schedule of tests performed at three mutually supporting levels: (1) systems, (2) subsystems, and (3) equipments. These integrated tests are designed to periodically test all combat system functions, parameters, and characteristics against specified tolerances. Successful equipment performance during the tests usually indicates that the systems are combat ready.

Integrated maintenance requirements are developed through engineering analysis, based on a study of all factors that significantly affect maintenance. The analysis defines system and equipment functions and sets tolerances (in terms of system parameters) that allow operators and technicians to determine if the systems are operating properly.

Integrated maintenance procedures provide minimum preventive maintenance coverage of the combat systems and are designed to test specific functions under specific conditions. Sometimes, equipment operators and technicians may not understand the purposes of all the tests. However, they must still follow the procedural sequences explicitly. Improvising or shortcutting procedural sequences of-ten leads to incorrect troubleshooting or masking of actual faults.

The integrated maintenance concept follows PMS principles and is the most effective way to achieve PMS goals. Compliance with this concept enables the SERT to manage the combat systems maintenance effort and to achieve the optimum level of readiness with the most effective use of available manpower.

Integrated maintenance is the planned maintenance system (PMS) as it relates to the maintenance documentation of a typical integrated combat systems, the PMS program, maintenance scheduling, and maintenance data system.

## PLANNED MAINTENANCE SYSTEM

Combat systems readiness requires efficient maintenance. The key to this capability is an organized system of planned maintenance to ensure the maximum operational readiness of the combat systems. *The Ships' Maintenance and Material Management (3-M) Manual,* OPNAVINST 4790.4, sets forth an effective PMS and assigns PMS management responsibility.

The PMS provides regularly scheduled tests to detect degraded performance and to prevent failures during tactical operations. When failures occur during combat systems operations, the PMS provides a formal step-by-step fault-isolation and repair procedure. Complete technical documentation (including combat systems, subsystems, and individual equipment manuals) is an integral part of the PMS. These manuals provide the necessary information for understanding, operating, and maintaining the combat systems.

Shipboard maintenance falls into the three following categories:

1. Organization-level maintenance: Maintenance within the capability of ship personnel.

2. Intermediate-level maintenance: Maintenance requiring assistance from outside the ship, such as a tender or an FTSC.

3. Depot-level maintenance: Maintenance requiring port facilities, such as shipyard maintenance.

The goal of PMS is to perform maintenance at the organization or intermediate level. Therefore, depot-level maintenance is not reflected in PMS.

The PMS is a planning and control system that prescribes a logical and efficient approach to complex mechanical, electrical, and electronic main-

tenance. It was developed to provide supervisors at each maintenance level with methods for effectively planning, scheduling, and controlling shipboard maintenance. It includes a maintenance data-collection system that is used to record important scheduled and corrective maintenance information, and an electronic data- processing capability that is used to retrieve this information for maintenance analysis.

The goal of PMS is maximum operational efficiency of all equipments and the reduction of equipment downtime, maintenance man-hours, and maintenance costs. Even though the PMS provides methods and resources to accomplish each goal, it is not self-sufficient and does not replace the initiative of maintenance supervisors or reduce the need for technically competent personnel. The recording and feedback of maintenance and personnel data allow continuing management analysis and improvement of maintenance methods and personnel use.

If the ship's force accepts the PMS program and makes fill use of its planning methods, the maintenance system will promote confidence and reliability. It will be capable of ensuring that the combat systems will be available when they are needed.

Data gathered from the fleet show conclusively that ships that adhere to their PMS schedule maintain a significantly higher state of materiel readiness with no greater maintenance manpower usage than ships that do not. The SERT concept is designed to ensure that the combat systems PMS is properly scheduled, managed, and used.

## PMS PROGRAM

The PMS program is essential to equipment readiness. The primary ingredients of the PMS program are as follows:

- Comprehensive procedures for planned maintenance of the combat systems, subsystems, and equipments.
- Systems fault-isolation procedures.
- Scheduling and control of maintenance task performance.
- Description of the methods, materials, tools, and personnel required for maintenance.

Adherence to the PMS program will provide the following results:

- Improved confidence in systems maintenance
- Reduced testing time
- Elimination of redundant testing resulting from lack of coordination
- Detection of most malfunctions during scheduled maintenance events

## MAINTENANCE SCHEDULING

The normal flow of events and requirements the SERT should use in developing an integrated maintenance schedule is illustrated in figure 4-5. This figure shows maintenance management responsibilities and the sequence of events that flows from the department master and work-center PMS record books (containing the maintenance index pages), through the scheduling tools (cycle, quarterly, and weekly schedules), to test actions, unscheduled maintenance, and reporting. However, due to the shipboard environment, it does not show the variants and constraints the SERT must consider in the quarterly, weekly, and daily scheduling.

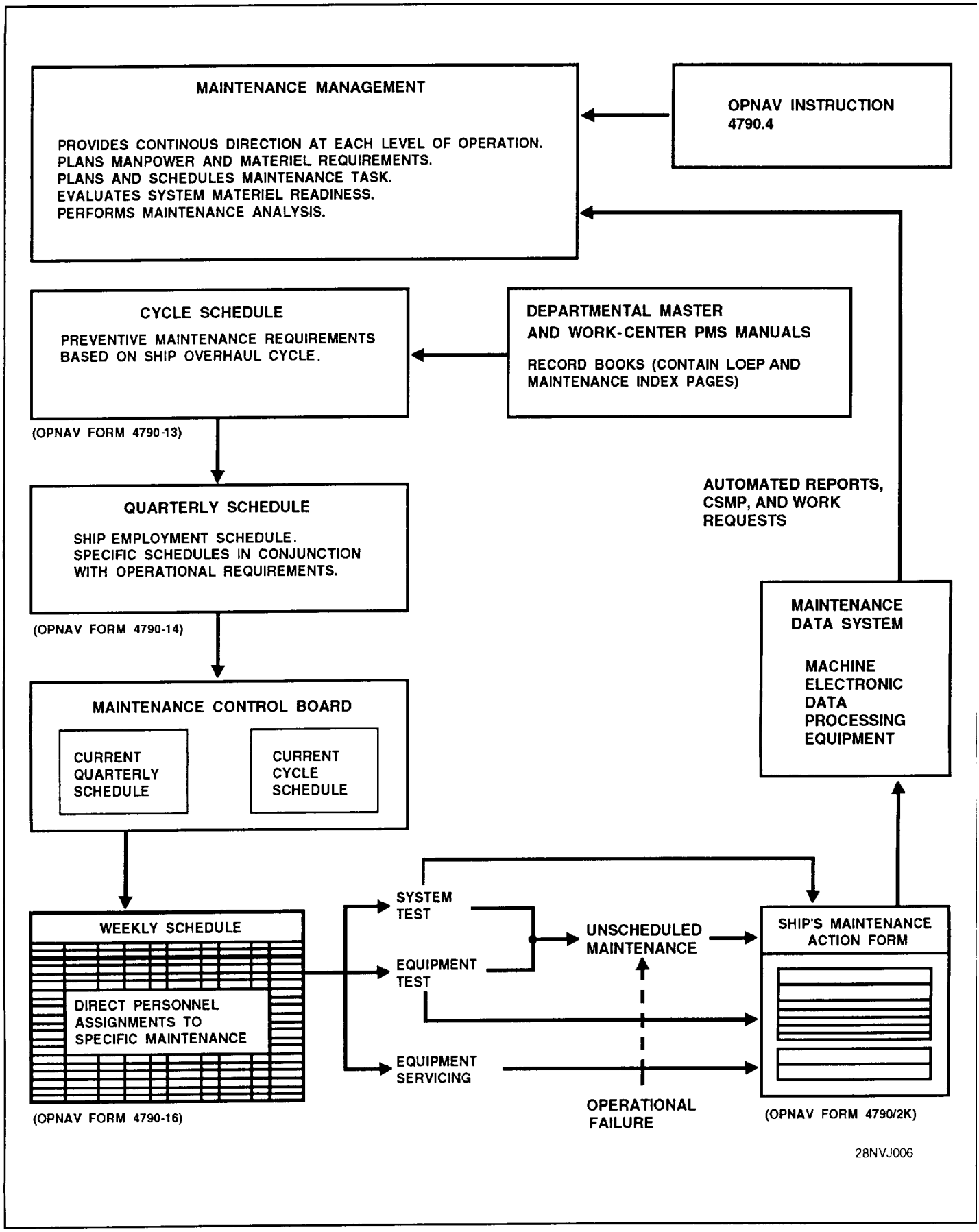


Figure 4-5.-Planned maintenance system.

### Maintenance Index Page

The maintenance index page (MIP) contains a brief description of the requirements on the MRC for each item of equipment, including the periodicity code, the man-hours involved, the minimum required skill level, and any related maintenance requirements.

The MIPs for all equipments in a department are contained in the departmental master PMS record, which the department head uses to schedule maintenance on the PMS schedule forms. Each work center should maintain a PMS record that contains the MIPs that apply to that work center.

### Cycle Schedule

The cycle schedule is used by the CSO to plan periodic maintenance and other requirements. It is a visual display of preventive maintenance requirements based on the ship's overhaul cycle.

### Quarterly Schedule

The quarterly schedule, planned from the cycle schedule, is a visual display of the ship's employment schedule. This schedule is prepared by the CSO in cooperation with division officers, maintenance group supervisors, system testing officers, and SERT members. It shows the current status of preventive maintenance for each group. The quarterly schedule assigns specific requirements in conjunction with the ship's operational schedule.

### Maintenance Control Board

The maintenance control board contains the cycle schedule and the current and subsequent quarterly schedules. The board summarizes the status of current and planned combat systems preventive maintenance.

### Weekly Schedule

The weekly schedule is a visual display that is posted in the working area of each maintenance group. The maintenance group supervisor uses this schedule to assign personnel to perform maintenance on specific equipment. Assignments include system and equipment tests and servicing procedures.

## MAINTENANCE DATA SYSTEM

The maintenance data system (MDS) provides a means of recording maintenance actions, processing the recorded data to define important facts about maintenance and equipment, and retrieving information for analysis. Significant data identified by the system include the reason for the malfunction, its discovery, the man-hours used in correcting the problem, the exact equipment affected, any delays in repair and their reasons, and the types of maintenance personnel required.

### Maintenance Actions

Maintenance personnel document certain shipboard maintenance actions and corrective maintenance on specific categories of equipment at the time they actually perform or defer the maintenance action. Information is recorded and put into the MDS using the Ship's Maintenance Action Form (OPNAV 4790/2K).

### Data-Processing Facilities

The MDS data-processing facilities collect, store, and analyze maintenance information inputs into the system. This information yields data concerning equipment maintainability and reliability, man-hours usage, equipment alteration status, materiel usage and costs, and fleet materiel condition.

Various automated reports are produced periodically for the ship, the repair activities, the unit commanders, and the type commanders. These automated reports include a ship's current maintenance project file, work requests, and preinspection and survey deficiency listings.

## MAINTENANCE TESTING

Integrated maintenance tests must be scheduled to reduce redundancy wherever possible. Combat systems testing is conducted at three levels: (1) systems, (2) subsystems, and (3) equipments. These three testing levels are described in the following subsections.

### SYSTEMS TESTING

Systems testing exercises the entire combat systems. It is the highest level of testing that can be done aboard ship. Combat systems tests are usually automated and monitored in the CDS subsystems.

Although these tests provide an overview of systems performance, they usually do not test the fill capabilities of the overall combat system itself. It is impractical, from an instrumentation and manpower standpoint, to test all the fictional requirements at the systems level. Therefore, confidence in operability or materiel readiness is mainly dependent on integrated testing at the subsystem or equipment level.

Systems-level tests provide a verification of the alignment between sensors; the on-line, real-time monitoring of combats system interfaces; and the overall test of the 3-D search radar and its interface with the CDS. These tests are described in the CSTOM.

### SUBSYSTEMS TESTING

Subsystems testing exercises two or more pieces of equipment fictionally contained within the same subsystem. The intent of subsystems testing is to test intrasubsystem (within the subsystem). However, with the need for integrated testing, some functions are tested intersubsystem (outside the subsystem).

The subsystems operability/readiness test is the keystone of integrated subsystems testing. This test consists of a rigidly controlled sequence of steps designed to test all critical functions during a primary mode of operation. The subsystems operability/readiness test and a supporting family of tests use the concept of end-point testing, in which functions are stimulated at their terminal point, thereby verifiing all operations within the function. Subsystems tests are functionally grouped and mode oriented so that related functions can be tested by using the same set-up, procedures, and stimuli.

### EQUIPMENTS TESTING

Equipments testing generally concerns power levels, frequencies, servos, special features, and output functions. The equipment PMS may require special external stimulating equipment for test measurements. These test measurements are often time-consuming and difficult to complete, but are always checked by the SERT to ensure optimum readiness.

## FAULT ISOLATION

The goal of fault isolation is to determine systematically the part or condition responsible for a fault or degraded operation during testing or tactical operation. The process often involves impact evaluation. Impact evaluation requires considering whether (1)

to ignore the problem for the time being; (2) to switch to alternate equipment; or (3) to perform corrective maintenance immediately. Impact evaluation information is provided in the CSTOM.

The CSTOM provides fault-isolation procedures, both for faults that were detected during operations and for faults that were known before the operations. After a fault has been isolated to a specific unit or interface, corrective action (repair, replacement, or alignment) must be taken. In the integrated maintenance concept, alignment is considered as corrective maintenance only and, like other corrective action, should be performed only when a fault is indicated.

Fault isolation leads to corrective maintenance. The corrective maintenance performed may or may not bring the system back to an operating condition. There may have been more than one fault contributing to the out-of-tolerance condition that started the fault-isolation process. (The SERT's responsibility for fault isolation was discussed earlier in this chapter under the heading "SERT Corrective Maintenance Management.")

The possibility of faulty replacement parts and incorrect adjustment or alignment also exists. Corrective maintenance may not have solved the problem; it may even have added to it. Therefore, each corrective action must be followed by verification. Verification normally is done by re-creating the test environment and rechallenging the function. Where alignments are concerned, the verification process is complicated by a requirement that the effect of the maintenance upon other elements of the combat systems be determined.

## RECOMMENDED READING LIST

**NOTE:** Although the following reference was current when this TRAMAN was published, its continued currency cannot be assured. Therefore, you need to ensure that you are studying the latest revision.

***COMNAVSURELANT Combat Systems Officers Manual,*** NAVSURFLANTINST 9093.3, Naval Surface Force, U.S. Atlantic Fleet, Norfolk, VA, 1986.

In addition:

Combat Systems Technical Operations Manual (CSTOM) for your class of ship.