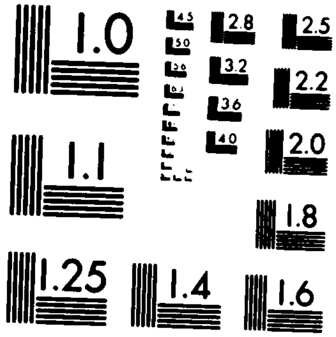
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NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

An Analysis of the Operational Level in the Combined Intermediate and Depot Level Maintenance Concept for Airborne Missile Systems

Eugene Klimson

December, 1987

Thesis Advisor: Fenn C. Horton

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The conclusion drawn from this policy analysis is that no changes should be made to the organizational level. Any changes that might be considered for the organizational level would not fulfill the goal of increasing productivity for maintaining equipment and systems as specified in the Secretary of the Navy's Action '88.

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An Analysis of the Operational Level in the Combined Intermediate and Depot Level Maintenance Concept for Airborne Missile Systems

by

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ABSTRACT

The purpose of this research effort is to determine what changes (if any) should be made to the organizational maintenance level for air-launched missiles if the Naval Air Systems Command adopts the omnibus maintenance concept. The omnibus maintenance concept would combine the intermediate and depot maintenance levels.

The conclusion drawn from this policy analysis is that no changes should be made to the organizational level. Any changes that might be considered for the organizational level would not fulfill the goal of increasing productivity for maintaining equipment and systems as specified in the Secretary of the Navy's Action '88.

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I. INTRODUCTION

To begin this analysis of maintenance programs for air-launched missiles in the Navy, it is necessary to understand the concept of the Integrated Logistics Support System (ILSS) of the Naval Air Systems Command (NAVAIR). OPNAVINST 8600.2 [Ref. 1:pg. 1-1-2] defines the Integrated Logistics Support System as:

> A comprehensive system designed to provide the management tools required for efficient and economical utilization of personnel and material resources to achieve readiness objectives.

Changes are planned for current maintenance programs because a need exists for increasing efficiency and economy in utilizing military personnel and resources. The starting point in the analysis would be a background in the key concepts and terms that are generally used in describing air-launched missile systems.

A. AIR-LAUNCHED MISSILES

In order to develop an understanding of air-launched missiles, the following descriptions of operational air-launched missiles, as described in TM000043 [Ref. 2:pp. 3-26], are listed:

(1) HARM: a supersonic, antiradiation, air-to-surface missile.
(2) HARPOON: a subsonic, radar guided, surface attack guided missile.

(3) PHOENIX: a radar guided, air-to-air, high explosive, long range missile.
(4) SHRIKE: a passive radar guided, air-to-ground missile.
(5) SIDEWINDER: a supersonic, infrared guided, air-to-air, short range missile.
(6) SPARROW: a supersonic, radar guided, air-to-air, medium range missile.
(7) SKIPPER: a laser guided, rocket propelled, air-to-surface missile.
(8) TOW: a wire guided, optical sight, high explosive, air-to-surface missile.
(9) HELLFIRE: a laser guided, air-to-surface missile.
(10) WALLEYE: a television guided glide bomb.

B. NAVAL AIR SYSTEMS COMMAND

OPNAVINST 8600.2 [Ref. 1:pg. 1-1-2] describes the Naval Air Systems Command as responsible for "The research, design, development, test, acquisition, quality evaluation and logistics support of all airborne weapons." The analysis presented here will deal specifically with the maintenance portion of logistics support. The other areas of responsibility (such as design, development, test, etc.) would not belong in an analysis of maintenance since the policy for maintenance organization has been established and is not being developed.

Naval Air Systems Command acts as the coordinating authority, according to OPNAVINST 8600.2 [Ref. 1:pg. 1-1-2], in providing:

> ... the airborne weapons maintenance policy guidance, procedures, technical direction and management review of the program [Naval Airborne Weapons Maintenance Program] at each level of maintenance, i.e., depot, intermediate and organizational.

It is Naval Air Systems Command, acting as the coordinating authority for maintenance of air-launched missiles, that is considering changing the present maintenance structure.

C. AIR-LAUNCHED MISSILE MAINTENANCE

The Naval airborne weapons maintenance program is divided into three levels:

1. Organizational (O)
2. Intermediate (I)
3. Depot (D)

These levels are defined in OPNAVINST 8600.2 [Ref. 1:pp. 1-1-7, 8] as follows:

> <u>Organizational Maintenance</u>:
> Organizational maintenance consists of those functions normally performed by an operating unit on a day-to-day basis in support of its own operations. Organizational Maintenance is usually accomplished by weapons personnel assigned to a maintenance department to support the missions and tasks of the performing activity. Organizational maintenance may be accomplished at the next higher [intermediate maintenance] level. Organizational level maintenance work generally can be grouped under the following functions:
>
> (1) Weapons receipt.
> (2) Weapons inspection.
> (3) Weapons handling, uploading and downloading.
> (4) On-aircraft test of armament system and weapon as required.
> (5) Installation and removal of wings, fins, fuzes, arming wires, etc.
>
> <u>Intermediate Maintenance</u>:
> Intermediate maintenance is the responsibility of, and is normally performed by Naval Weapons Stations (WPNSTAs) and Mobile Missile Maintenance Units (MMMUs) in support of using organizations. This level of maintenance normally consists of testing All-Up-Rounds (AURs) and section replacement and also includes the following:

(1) Receipt, Segregation, Storage and Issue (RSSI) of airborne weapons, sections and all-up-rounds.
(2) Repair, test, modification and/or check of designated intermediate level test equipment.
(3) Intermediate level calibration of designated equipments.
(4) Providing technical assistance and field teams, when required, to the supported units.
(5) Assembly, disassembly, testing, and package/unpackaging of weapons and sections.
(6) Storage and storage monitoring.
(7) Performing authorized repair of Weapons Replacement Assemblies (WRAs) using Shop Replaceable Assemblies (SRAs).
(8) Disposition of all Weapons Replacement Assemblies and Shop Replaceable Assemblies to depot level maintenance which are Beyond Capability of Maintenance (BCM) at this level.

Selected Intermediate Maintenance:
When authorized and so designated as an Intermediate Maintenance Activity (IMA), a Naval Air Station (NAS), Marine Air Group (MAG), or Shipboard Weapons Department performs some or all of the following maintenance actions:

(1) Receipt, storage and issue of airborne weapons, sections and all-up-rounds.
(2) Minor repair.
(3) Assembly, disassembly, testing and packaging/unpackaging of weapons and sections.
(4) Storage monitoring.

Depot Maintenance:
Depot maintenance is performed on airborne weapons commodities requiring major overhaul or a complete rebuilding of parts. It includes assemblies, subassemblies and the end items, including the manufactured parts, modifications, testing and reclamation. Depot maintenance activities support lower categories of maintenance by providing technical assistance and performing that maintenance beyond the capability of the lower level activities. It provides more extensive facilities for repair than lower level maintenance activities. Those functions may be grouped as follows:

(1) Overhaul and major repair of airborne weapons, sections and certain related support equipment.
(2) Maintenance of test equipment.
(3) Incorporation of designated technical directives.

(4) Modification of airborne weapons, sections, components and certain related equipment.
(5) Manufacture/modification of designated parts/kits. Depot and intermediate activities may have the capability to perform some lower level maintenance actions as defined above.

D. THE ALL-UP-ROUND CONCEPT

The organizational and intermediate maintenance levels are presently utilizing the all-up-round concept for all missiles received aboard aircraft carriers (CV/CVN/CVA), amphibious helicopter carriers (LHA/LPH) and ammunition supply ships (AEs).

The All-Up-Round (AUR) concept evolved from the Chief of Naval Operation's Improved Rearming Rate System (IRRS). OPNAVINST 8600.2 [Ref. 1:pg. 2-9-1] describes the Improved Rearming Rate System as follows:

> The Improved Rearming Rate System was initiated to maximize the full capability of the carrier based aircraft. The overall objective of Improved Rearming Rate System is to achieve maximum effectiveness of integration and coordination among operating systems directed at minimizing initial sortie response time and sortie recycle time. The objectives of the Improved Rearming Rate System are:
>
> (1) to optimize support equipment quantities and capabilities.
> (2) to optimize airborne weapon strike up[1] rates.
> (3) to optimize airborne weapon strike down[2] rates.
> (4) to optimize methodology training for weapons personnel.
> (5) to minimize sortie recycle time.
> (6) to minimize alongside time for replenishment.

[1] strike up: uploading the missile for flight.

[2] strike down: downloading and stowage of the missile after flight.

The all-up-round is a fully assembled missile system which is treated as a single unit. It requires minimal inspection or testing while onboard ship. The only authorized disassembly of the all-up-round is at a Naval Weapons Station or a Mobile Missile Maintenance Unit. Shipboard personnel are restricted to performing "go/no-go" tests of the all-up-round when it is installed on the aircraft.

Prior to the establishment of the Improved Rearming Rate System and the all-up-round, air launched missiles were transported and stowed as separate components. The explosive components (warhead and propulsion sections) were segregated from the inert components (guidance, seeker and control sections). Aboard ship, the inert sections were periodically tested and assembled into an all-up-round, then placed in a ready-service[3] magazine. With different missile types, standardization of maintenance was difficult.

The Improved Rearming Rate System for the all-up-round concept moved the assembly point from the shipboard environment to the Naval Weapons Stations. The depot would transport the individual components to the Naval Weapons Station where the m_ssiles would be assembled into all-up-rounds for delivery to the fleet. The all-up-rounds would be packaged in containers which stressed minimal handling conditions and maximum stowage density configurations.

---

[3] ready service: fully assembled and ready to be placed on the aircraft

Onboard the ships, the fully assembled all-up-rounds would remain in their shipping containers and stored in magazines. The all-up-rounds would remain in their containers until needed, at which point the missile would be removed from its container and placed in ready service. Unless specifically designated as requiring periodic checkout or issue to ready service, the all-up-rounds would remain in "deep stowage"[4] and not moved until the completion of the deployment (6-9 months). If a missile is used in flight (captive flight), then it must return to the intermediate level for inspection and testing. OPNAVINST 8600.2 [Ref. 1:pg. 3-2-2] explains the reason for the extensive maintenance on captive flight missiles as primarily:

> ... due to the repetitive requirement to energize the internal components of the missile during tests on the aircraft during training missions, aborted tactical missions, and the forces of acceleration/deceleration associated with the carrying aircraft.

Missiles that are removed from their containers are used to the point where they can no longer pass aircraft tests. It is only then that the missile is removed from ready service and another missile from "deep stowage" takes its place. OPNAVINST 8600.2 [Ref. 1:pg. 3-2-2] explains the reason for this action as follows:

[4] deep stowage: OPNAVINST 8600.2 [Ref. 1:pg. 3-2-4]: "Missiles or components stored in an environmentally protected container since their last Naval Weapons Station processing."

This extensive maintenance can be minimized by captive carrying [captive flight] a missile repetitively until the missile experiences a verified failure as indicated by the aircraft test system, end of deployment, or until the MDD [Maintenance Due Date] is reached.

E. THE OMNIBUS MAINTENANCE CONCEPT

The omnibus maintenance concept is being considered by Naval Air Systems Command to fulfill productivity goals ordered by the President. This concept combines the intermediate and depot maintenance levels into one intermediate/depot level. Under this new maintenance concept, a suspect or defective all-up-round would be returned directly from the organizational level to the intermediate/depot level. A point paper produced for AIR 418 [Ref. 5:pg. 1] states:

> Functions currently performed at the intermediate level would be eliminated and would be performed at the new intermediate/depot level under this concept.

The omnibus maintenance concept evolved as a result of Executive Order 12552 of February 25, 1986 [Ref. 4:pg. 7041]:

> There is hereby established a government-wide program to improve the quality, timeliness, and efficiency of services provided by the Federal government. The goal of the program shall be to improve the quality and timeliness of service to the public, and to achieve a 20 percent pro ductivity increase in appropriate functions by 1992. Each Executive department and agency will be responsible for contributing to the achievement of this goal.

This Executive Order lead to the establishment of Action '88 by the Secretary of the Navy (SECNAV) in order to fulfill the requirements stated in Executive Order 12552. In a message sent by the Secretary of the Navy on 17 Nov 1986

[Ref. 5], the focus of Action '88 was directed towards the following areas of improvement:

(1) Acquisition streamlining
(2) Value engineering
(3) Productivity Improvement

The Assistant Secretary of the Navy (Shipbuilding and Logistics) directed the productivity improvement effort towards a combined intermediate and depot maintenance level (the omnibus concept) utilizing the all-up-round philosophy. The intermediate/depot level would perform all of the functions of the current intermediate level except those functions associated with Receipt, Storage, and Issue (RS&I) functions at the waterfront.

II. NATURE OF THE PROBLEM

Naval Air Systems Command is considering adapting the intermediate/depot maintenance level to air-launched missiles (the omnibus maintenance concept). The analysis of this research effort is centered on what changes (if any) should be made at the organizational level of maintenance if the intermediate/depot level is created.

The present logistics chain for missile repair is:

(1) SHIP<----->Naval Weapons Station<----->DEPOT

If the organizational level assumes the repair capability which now exists at the Naval Weapons Stations, then the logistics chain would be shortened to:

(2) SHIP<--------->DEPOT

with the Naval Weapons Stations acting as a transfer point for missiles from ship to shore and vise versa.

The omnibus maintenance concept would combine the intermediate and depot levels, creating the following logistics chain:

(3) SHIP<--------->INTERMEDIATE/DEPOT

with the Naval Weapons Station acting as a transfer point.

The difference between logistics chain (2) and (3) is that intermediate level repairs would be accomplished onboard the ship, as opposed to logistics chain (3), which would continue the all-up-round concept for onboard missiles maintenance.

A. ASSUMPTIONS

The ability to repair missiles onboard the aircraft carrier would increase the probability of retaining a missile which would have been offloaded had that capability not existed. This assumes that the repairs are of a nature which the shipboard personnel are capable of satisfactorily completing with functional test equipment and that the necessary repair parts were available in the ship's inventory.

To achieve this repair capability, the facility, test equipment, personnel, training, and supply parts must be accommodated onboard the ship. This assumes that the ship has the area and weight allowance to handle the increased volume and weight which this type of facility would necessitate.

There are also assumptions to be made concerning the future environment in which the intermediate/depot level maintenance will operate. An AIR 418 Industry Brief of July, 1987 [Ref. 6:pg. 3] list these assumptions as follows:

- Current World Political environment will remain stable
  - No major confrontation - small exigencies only
  - Current weapons will not be phased out
- Fiscal outlook is austere
  - Increased competition for national resources
  - Maintenance budget growth will not match inventory growth
  - Military construction budgets will remain stable or decrease
  - Fiscal accountability and execution will be stressed

Missiles and UAV/RPVs[5] will drive the maintenance workload

Maintenance advantages will have to be gained through:
- Standards development
- Consolidation of workload
- Competition
- Productivity improvements

B. LOGISTIC SUPPORT OF A REPRESENTATIVE MISSILE SYSTEM

A way to approach this analysis is to determine the point where the organizational and intermediate maintenance levels can be differentiated and increase current efficiencies in logistic support. To do this, the following areas of logistics support will be discussed:

(1) Maintenance

(2) Test equipment

(3) Facilities

(4) Personnel training

A detailed description of one type of missile would illustrate the problems inherent in altering the logistic's system of the remaining operational missile systems. The representative missile in this analysis will be the HELLFIRE Integrated Logistic Support Plan.

HELLFIRE Integrated Logistic Support Plan

a. Maintenance

A complete description of the maintenance levels for the HELLFIRE missile is contained in the Integrated Logistic Support Plan (ILSP No. MS-067). The Integrated Lo-

[5] UAV: Unmanned air vehicle
RPV: Remotely piloted vehicle

gistic Support Plan uses the three maintenance levels, with the intermediate level differentiated into Fleet (shipboard personnel) and Naval Weapons Station personnel. ILSP No. MS-067 [Ref. 7:pp. 3-11 - 3-12] describes these levels:

Maintenance Concept Details - Tactical Missile

a. Organizational Level
   (1) Visual inspection for damage
   (2) Uploading/downloading of missiles
   (3) Visual inspection of mating with launcher
   (4) Use of aircraft BIT[6] capabilities to test the following while the missile is loaded on the aircraft:
      (a) HELLFIRE missile control system
      (b) Launcher
      (c) Missile
   (5) Clean the seeker lens

b. Intermediate Level Fleet
   (1) All-up-round decanning and canning [from the container]
   (2) Visual inspection for damage and corrosion
   (3) Corrosion control
   (4) Return all-up-round to Naval Weapons Station

c. Intermediate Level Naval Weapons Station
   (1) All-up-round decanning and canning
   (2) Visual inspection for damage and corrosion
   (3) Corrosion control
   (4) All-up-round test
   (5) Fault isolation of all-up-round to a section (seeker, warhead, propulsion or control)
   (6) Remove/replace faulty section
   (7) Recertification of all-up-round
   (8) Prepare faulty section for transportation
   (9) Return of faulty section to the Designated Overhaul Point (DOP)/Depot
   (10) Remove/replace wire harness enclosure
   (11) Remove/replace intermediate and rear launch shoes
   (12) Remove/replace seeker mounting frame assembly
   (13) Prepare all-up-round for shipping and storage
   (14) Remove/replace fins

---

[6] Built-In-Test

d. Depot Level

Repair of missile sections beyond capability of maintenance of the Naval Weapons Station

The present system of maintenance, as listed above, has a distinct difference between the intermediate level (fleet) and the intermediate level (Naval Weapons Station). The intermediate level (Naval Weapons Station) can perform intermediate level (fleet) maintenance actions. However, the intermediate level (Naval Weapons Station) performs more detailed maintenance procedures including fault isolation of the missile sections. The dividing line between intermediate level (fleet) and intermediate level (Naval Weapons Station) is drawn at the ability to localize and repair faults in the various sections of the missiles. It is necessary, therefore, to describe the support equipment that would be required to accomplish this area of maintenance.

b. Test and Support Equipment

Continuing with the HELLFIRE missile, ILSP No. MS-067 [Ref. 7:pg. 6-1] describes the test equipment required for each maintenance level:

1. Organizational Level Test Sets
   No missile test sets are required at the organizational level.

2. Intermediate Level Test Sets (Fleet)
   No missile test sets are required at the intermediate level (fleet).

3. Intermediate Level Test Set (Naval Weapons Station)
   The TS-100 Missile Test Set (including the 825 adapter) [Figure 1], is an Army missile test set which will be used by the Navy. The test set provides sig-

nals to simulate those normally provided by the aircraft/launcher and monitors the response of the missile to a simulated target. The test set obtains its operating power from 115 volt A.C. and 220 volt A.C. facility power. The 50-foot cables and the fixtures required to support the missile test cell and to provide restraint in case of an inadvertent motor firing during test are part of the test set. The physical properties of the test set are shown in Table 1:

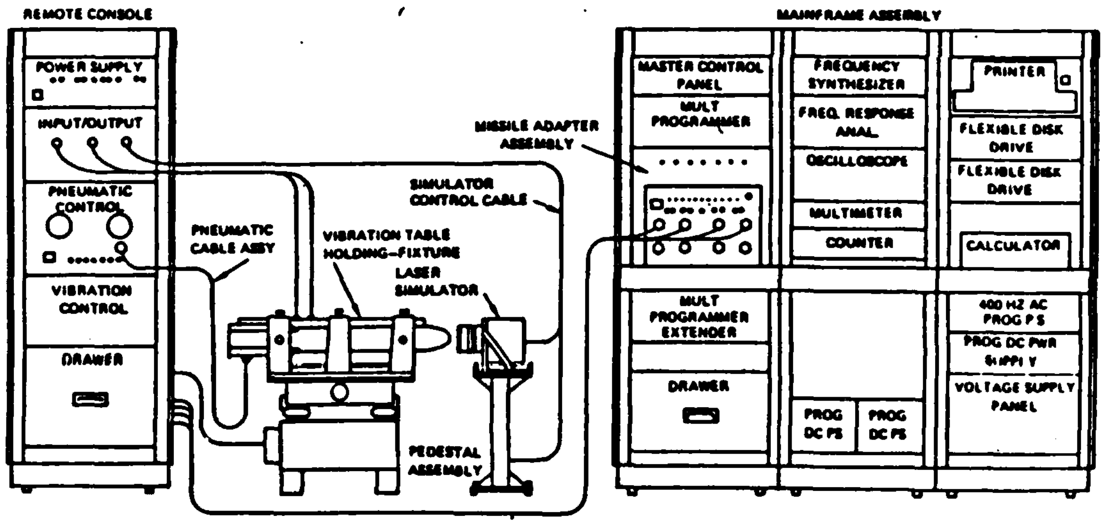

FIGURE 1. TS-100 TEST SET'

'Source: ILSP No. MS-067 [Ref. 7:pg. 6-8]

TABLE 1. TS-100 Missile Test Set Physical Properties[a]

Equipment	Dimensions (Inches) Width	Height	Depth	Weight (lb)(±15%)
Mainframe Assembly	67.88	61.38	25.50	1800
Remote Console Assembly	22.16	61.38	25.63	150
Electronic Adapter Assembly	16.50	10.75	12.25	40
Vibration Table Assembly	30.00	46.00	54.75	760
Target Simulator Assembly	27.00	46.00	26.00	125

4. Maintenance Concept For Missile Associated Peculiar Support Equipment

The maintenance tasks during in-service use of missile associated Peculiar Support Equipment (PSE) are as follows:

a. Organizational Level - None
b. Intermediate Level (Fleet) - None
c. Intermediate Level (Naval Weapons Station) - TS-100 Test Set with the Missile Test Set Assembly

   (1) Calibration as scheduled/required
   (2) Corrosion control
   (3) Repair actions to be defined in the Maintenance Plan
   (4) Fault isolation to component level
   (5) Removal/replacement of Automatic Test Equipment (ATE) components not coded for Designated Overhaul Point repair
   (6) Return of faulted Designated Overhaul Point coded items to the Designated Overhaul Point

d. Depot Level - TS-100 Missile Test Set
All PSE maintenance functions beyond the capability of intermediate maintenance will be performed at the Designated Overhaul Point.

The ability to localize and repair faults in missile sections is made possible with the TS-100 missile test set.

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[a] Source: ILSP No. MS-067 [Ref. 7:pg. 6-2]

If the propulsion section is to be tested, then safety requirements mandate that the facility is adapted to protect against the inadvertent firing of the propellant.

c. Facilities

ILSP No. MS-067 [Ref. 7:pp. 8-16 - 8-17] lists the following equipment that would be accommodated onboard a ship if the missile maintenance is upgraded to intermediate level (Naval Weapons Station):

Naval Weapons Station Facilities Requirements for USN Intermediate level - Naval Weapons Station Missile Maintenance Facility

Equipment to be accommodated:
(1) TS-100 missile test station consisting of:
    Mainframe assembly
    Remote control assembly
    Electronic adapter assembly
(2) Missile test stand (vibration table assembly)[9]
    Target simulator assembly
(3) Single missile all-up-round container
(4) Section containers
(5) All-up-rounds and missile sections
(6) Overhead hoist
(7) Hoisting beam
(8) Missile assembly stand
(9) Launch shoe alignment tool
(10) Grounding strap assembly

d. Personnel Training

If intermediate level abilities are to be accomplished onboard a ship, then the area of training required for shipboard personnel would be the type of training which Naval Weapons Station personnel receive in order to service

[9] The missile test stand bolted to the floor is capable of restraining the missile in the event of accidental motor ignition.

missile systems. Training for the other maintenance levels would remain the same. ILSP No. MS-067 [Ref. 7:pp. 4-3] describes this training as follows:

> Naval Weapons Station Personnel Training
>
> RI[10] will provide for the training in maintenance and operation of the TS-100 test set including the assembly/disassembly of the missile for the Naval Weapons Station personnel as indicated ...
>
> Training Requirement
> HELLFIRE Intermediate Maintenance - Naval Weapons Station
>
> Objective
> To provide training for intermediate maintenance personnel at Naval Weapons Station Fallbrook and Naval Weapons Station Yorktown, ... for the HELLFIRE missile, including missile theory and functional analysis, can/decan, operation and maintenance of TS-100 missile test set and missile containers.

C. OBJECTIVES

The objective of the omnibus maintenance concept is to increase system productivity. Productivity is defined in Mansfield [Ref. 8:pg. 511] as "The ratio of output to input." Gaither [Ref. 9:pg. 654] expands on the concept of productivity in terms of improvement as follows:

> Improving productivity means a continuous effort to drive down the cost of doing business. This activity involves reducing material costs, shipping costs, costs of production workers, cost of white collar or knowledge workers, and all overhead costs. This objective must be balanced by a cost objective which would be tied directly to increasing that productivity.

For this analysis, the criteria of productivity would be cost considerations for input and availability considera-

[10] Rockwell International

tions for output. Availability in this context would be the probability that an air-launched missile will be available for use when it is needed.

D. CRITERIA

1. Availability

The optimal figure for availability would be 100%. This would result in always having the missile system ready for use. If each ship were modified in order to complete intermediate level (Naval Weapons Station) repairs, then availability would increase by the amount that is now lost through the transportation delays of returning a defective missile back to the Naval Weapons Station. However, the increase of availability resulting from the ability to do repairs would be offset by the delays in repair time on the missile, repair time on the test equipment, parts delay (if that specific part is not aboard) and personnel delay (if the technician responsible for the repair is not available).

2. Cost Analysis

To balance availability, costs must be considered in order to determine what resources will be used. Blanchard [Ref. 10:pp. 369-399] uses a cost breakdown structure which can be modified for this example:

a. Operations and Maintenance cost:

Blanchard [Ref. 10:pg. 379-380] describes this category as follows:

> Includes all costs associated with the operation and main tenance support of the system throughout its life cycle subsequent to equipment delivery in the field. Specific categories cover the cost of system operation, maintenance, sustaining logistic support, equipment modifications, and system/equipment phaseout and disposal.

By examining the maintenance actions and facilities needed for each maintenance level, a change in the shipboard organizational level would increase each of the following costs in the operations and maintenance cost category described by Blanchard [Ref. 10:pp. 379-390]:

(1) Operating cost
(2) Operating personnel cost
(3) Operator training cost
(4) Operational facilities cost
(5) Support and handling equipment cost
(6) Maintenance cost
(7) Maintenance personnel and support cost
(8) Corrective maintenance cost
(9) Preventive maintenance cost
(10) Spare/repair parts cost
(11) Test and support equipment cost
(12) Transportation and handling cost
(13) Maintenance training cost
(14) Maintenance facility cost
(15) Technical data cost
(16) System/equipment modification cost

b. Initial logistic support cost

This is a one-time cost added to the operations and maintenance cost which would be created if the present maintenance policy is altered for the organizational level. Blanchard [Ref. 10:pg. 377-379] describes this category as follows:

> Includes all integrated logistic support planning and con trol functions associated with the development of system support requirements, and the transition of such require ments from supplier(s) to the applicable operational site.

This initial logistic support cost category includes the following costs described in Blanchard [Ref. 10:pp. 377-378]:

(1) Logistic program management cost
(2) Cost of provisioning
(3) Initial spare/repair part material cost
(4) Initial inventory management cost
(5) Cost of technical data preparation
(6) Cost of initial training and training equipment
(7) Acquisition cost of operational test and support equipment
(8) Initial transportation and handling cost

E. ALTERNATIVES

The organizational maintenance level could be altered in one of three ways:

(1) Status quo: no change in the organizational maintenance level.

(2) Increase the organizational maintenance level for the fleet with repairs limited to those which would not require the use of test equipment.

(3) Increase the organizational maintenance level to include the ability to localize and repair faults in the missile system down to individual component parts (warhead, propulsion, guidance, seeker and control sections). This alternative is one that would return the organizational level to a status quo ante which existed before the introduction of the all-up-round concept.

There is a distinction between alternatives (2) and (3). The ability to localize and repair faulty components results in an "all or nothing" decision when the facility alteration and test equipment expenditure is realized. It would not be possible to accomplish any testing of a missile system without an equipment set-up such as that in Fig. 1. This will change if an "all-purpose" test set is developed and all missile systems are modified in a way that allows testing on this one test set. For this analysis, an additional assumption will be made that the "all-purpose" test set will not be operational and could be neglected as an alternative.

F. IMPACTS

If alternative (1) (status quo) is considered, then the intermediate/depot maintenance level would not be affected by the organizational level. Missiles would continue to be delivered as all-up-rounds to the ships via Naval Weapons Stations. An adverse impact of this alternative is an intermediate/depot level maintenance facility that is not located near a Naval Weapons Station. This would require extending the transportation loop which could be subject to logistic delays.

Alternative (2) requires consideration of logistic delays in spare part requirements and the increase of the present parts supply onboard each ship to accommodate this change. The actual repairs that can be accomplished by shipboard personnel is very limited without the capability to test component parts of the missiles. From the maintenance descriptions of the HELLFIRE, the intermediate level (Naval Weapons Station) has four external repairs to the missile which could be done without localizing and repairing the components. However, these repairs are accomplished by the intermediate/depot level as part of their all-up-round assembly and would be necessary in the instances where shipboard handling has damaged external parts. The impact of this decision would be the costs associated with supplying the repair parts and the improvement of technical skills required of the shipboard personnel.

Alternative (3) (status quo ante) would decrease the transportation loop for missiles which would have been returned to a Naval Weapons Station because of faulty components or external damage. The adverse impacts are considerably higher than the single favorable impact listed above. These impacts would result from the consideration of costs and modifications which would be balanced against shortening of the transportation loop. Shipboard modification would be greatly impacted by this alternative when considering the volume and weight of each of the test sets (Table 1). All costs listed in the cost analysis would be substantial with each category adding to the total cost impact. The additional impact of test set availability would also be considered as a possible delay to modification of shipboard systems.

III. CONCLUSION

The reason for the omnibus concept is to enhance productivity as specified in the Action '88 goals. In considering the organizational maintenance level, the greatest impact to the goal of productivity would be the ability to service missile systems onboard the ships. Availability of missile systems would increase over the present configuration, however, this would cause a greater expenditure of resources to accomplish.

A. EVALUATION

The status quo alternative can be viewed from a set of results from the latest deployment of an aircraft carrier.

U.S.S. Constellation 1987 Deployment

The U.S.S. Constellation (CV-63) has completed an excended deployment to the Western Pacific which included Arabian Sea operations. The following is a table (Table 2) of percentages of missiles used on this deployment:

TABLE 2. LIST OF PERCENTAGES OF MISSILES USED BY U.S.S. CONSTELLATION (CV-63) 1987 DEPLOYMENT''

	% REMOVED FROM DEEP STORAGE	% REMOVED FOR CAPTIVE CARRY	% OF FAILED CAPTIVE CARRY
SIDEWINDER	38%	38%	26%*
SPARROW	67%	67%	21%**
PHOENIX	22%	22%	5%***
HARM	9%	0	0
HARPOON	4%	0	0

The percentages of missiles which failed aircraft tests is greater than those which failed due to external damage. This would suggest that the majority of missiles returned to the intermediate level (Naval Weapons Station) required the capability to repair component parts.

The list of missiles used on this deployment is limited to a small number of the inventory that is available (as shown in the the list of the air-launched missiles in the introduction). Therefore, the decision for choosing the status quo ante alternative has the additional burden of deciding what missile systems to support with test sets.

The status quo ante alternative becomes less suited to the productivity goals of the omnibus concept when procurement is considered. The number of test sets required would

''Source: Corbett [Ref. 11]

*5% of missiles had damaged radome, remainder failed tone test [built-in-test]

**43% of failed missiles were broken radomes, remainder failed tone test

***missiles failed due to coolant leaks

be calculated as the number of missile systems multiplied by the number of ships which would be considered for the modifications. Table 3 lists the numbers of air-launched missile ships from Polmar [Ref. 12:pp. 80, 185, 239]:

TABLE 3. AIR-LAUNCHED MISSILE SHIPS

Ship type	Active	Scheduled to be built
Aircraft carriers (CV, CVN, CVA)	14	3
Amphibious helicopter carriers (LHA, LPH)	12	
Ammunition ships (AE)	13	

TOTAL: 42 ships

The status quo ante alternative should be viewed not only in numbers of test sets, but also in terms of the weight and volume of each of the test sets (the HELLFIRE weight and volume as an example) that would be added to the configuration of each of the ship types. All operational ships have long since abandoned the status quo ante alternative. An example of this is the U.S.S. Constellation (CV-63) which has modified the previous missile repair areas for other uses. The addition of any missile test set would require extensive modification to shipboard systems in order to accommodate a list of equipment such as that for the HELLFIRE (described earlier in this study). If the ability to isolate faults in the propulsion section is considered, then substantial safety requirements have to be met in order to minimize the accidental ignition of the missile. These safety requirements would require a space onboard the ship where the rocket motor can burn without injury to personnel or equipment.

The final area of concern that needs to be considered for the status quo ante alternative is the upgrading of personnel training necessary to accomplish the repairs that are now done by Naval Weapons Station personnel. The limited training of all-up-round maintenance and handling that exists for shipboard personnel is geared to treating the missile systems as whole units. An upgrade in training would require a substantial increase in the technical knowledge of electronic repair for the present shipboard personnel. This upgrade would require an increase in the number of instructors and modification of present teaching facilities to accomplish that purpose. The additional technical training would require either the recruitment of new technical personnel from the outside or the transfer of shipboard personnel for training.

The remaining alternative (upgrading organizational level to repairs which require no fault isolation of individual components) has similar drawbacks as the status quo ante alternative. The productivity goals would not be met with this alternative when the costs of supplying each ship with the necessary repair parts is considered. The additional training and repair facility modifications that would be required to accomplish these repairs would also add to the cost of implementation. In Table 2, only the SPARROW missile would benefit from this alternative. The remaining failed missiles would require the ability to isolate faults. As a whole, the upgrade in repair abilities would not justify the modification of the present organizational level when the cost of the modification is compared to the number of missiles involved.

B. CONCLUSIONS

The conclusion that is drawn from the analysis is that the organizational maintenance level remain "as is" in the omnibus maintenance concept. The productivity goals of Action '88 would be best served with the organizational level remaining as specified in the Naval Airborne Weapons Maintenance Program (OPNAVINST 8600.2). The remaining two alternatives would not meet the goal of increased productivity when cost impacts are considered. The benefits which could be found in these two alternatives are outweighed by the cost in resources.

C. RECOMMENDATIONS

The ability to isolate and repair faults in a missile system would require the use of individual test sets for each system. A move towards standardizing the missile systems to only one test set would change the final outcome of this analysis. The complexity and costs associated with upgrading the organizational level would not be the same if a single portable test facility were available to the fleet.

The recommendation of this research effort is a possible study of the feasibility of a general test set for all operational and developmental missile systems. This would require logistic support analysis from the developmental and deployment phases of the acquisition process.

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