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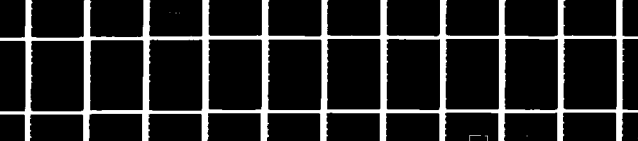
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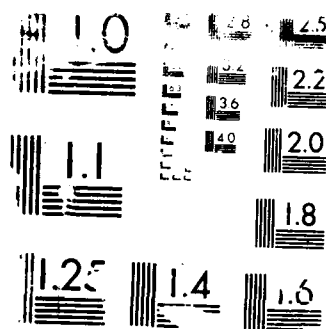
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U.S. GOVERNMENT PRINTING OFFICE: 1964

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AN ANALYSIS OF SPARROW MISSILE MAINTENANCE

by

Paul E. Gonzales

December 1987

Thesis Advisor:

Paul M. Carrick

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88 2 12 072

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED			1b. RESTRICTIVE MARKINGS		
2a. SECURITY CLASSIFICATION AUTHORITY			3. DISTRIBUTION / AVAILABILITY OF REPORT Approved for public release; distribution unlimited.		
2b. DECLASSIFICATION / DOWNGRADING SCHEDULE					
4. PERFORMING ORGANIZATION REPORT NUMBER(S)			5. MONITORING ORGANIZATION REPORT NUMBER(S)		
6a. NAME OF PERFORMING ORGANIZATION NAVAL POSTGRADUATE SCHOOL		6b. OFFICE SYMBOL (If applicable) 54	7a. NAME OF MONITORING ORGANIZATION NAVAL POSTGRADUATE SCHOOL		
6c. ADDRESS (City, State, and ZIP Code) MONTEREY, CA 93943-5000			7b. ADDRESS (City, State, and ZIP Code) MONTEREY, CA 93943-5000		
8a. NAME OF FUNDING / SPONSORING ORGANIZATION		8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER		
8c. ADDRESS (City, State, and ZIP Code)			10. SOURCE OF FUNDING NUMBERS		
			PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.
11. TITLE (Include Security Classification) AN ANALYSIS OF SPARROW MISSILE MAINTENANCE					
12. PERSONAL AUTHOR(S) GONZALES, PAUL, E.					
13a. TYPE OF REPORT Master's Thesis		13b. TIME COVERED FROM _____ TO _____		14. DATE OF REPORT (Year, Month, Day) December 1987	
15. PAGE COUNT 61					
16. SUPPLEMENTARY NOTATION					
17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number) Missile Maintenance		
FIELD	GROUP	SUB-GROUP			
19. ABSTRACT (Continue on reverse if necessary and identify by block number) It is anticipated that the Air-Launched Missile maintenance budget will not increase sufficiently enough to keep pace with maintenance requirements. One option of cutting costs is to decrease overhead by combining facilities. This thesis studies the proposal to combine depot and intermediate level maintenance for Sparrow Missiles. The missile maintenance organization, cycle, performance, and costs are outlined. Factors influencing delays in the maintenance cycle are discussed. A method of determining the impact on total missile inventory costs for one day of maintenance is developed.					
20. DISTRIBUTION / AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS				21. ABSTRACT SECURITY CLASSIFICATION Unclassified	
22a. NAME OF RESPONSIBLE INDIVIDUAL Professor Paul M. Carrick				22b. TELEPHONE (Include Area Code) (408) 646-2939	
				22c. OFFICE SYMBOL 54CA	

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An Analysis of Sparrow Missile Maintenance

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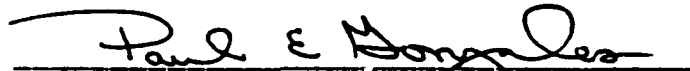
Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN MANAGEMENT

from the

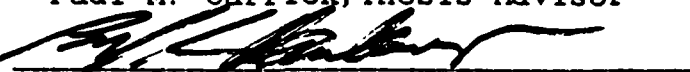
NAVAL POSTGRADUATE SCHOOL
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Author:

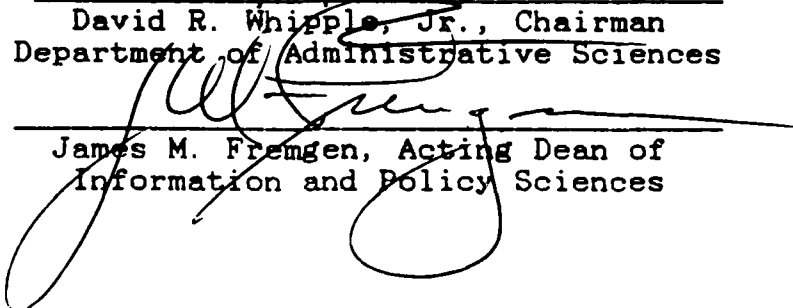

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ABSTRACT

It is anticipated that the Air-Launched Missile maintenance budget will not increase sufficiently enough to keep pace with maintenance requirements. One option of cutting costs is to decrease overhead by combining facilities. This thesis studies the proposal to combine depot and intermediate level maintenance for Sparrow Missiles. The missile maintenance organization, cycle, performance, and costs are outlined. Factors influencing delays in the maintenance cycle are discussed. A method of determining the impact on total missile inventory costs for one day of maintenance is developed.

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I. INTRODUCTION

A. PURPOSE

The purpose of this thesis is to do an analysis of Air-Launched Missile (ALM) maintenance for Sparrow missiles, and determine if it would be feasible to combine the Depot and Intermediate level maintenance into a single site. This may allow the Navy to cut costs or operate more efficiently. In order to accomplish this, the present three levels of maintenance, Organizational (O), Intermediate (I), and Depot (D) level will be reviewed. The type of maintenance, how it is costed out and budgeted for will be traced. Finally, an analysis will be done on the proposal to combine intermediate level and depot level maintenance into a single site. Due to the recent defense buildup, there has been an increasing number of missiles purchased. As these missiles are issued to the fleet, they will have to be returned for maintenance. It is anticipated that the maintenance budget will not increase sufficiently to keep pace with the maintenance requirements in future years. Ways to eliminate overhead, combine workforce, and shorten turnaround time must be made if the fleet is to maintain an acceptable level of operational readiness.

B. RESEARCH QUESTION

To Analyze the maintenance program for Sparrow missiles within the U.S. Navy. Upon completion of the study, determine if there are ways to reduce costs without reducing readiness and compare that to the baseline.

C. RESEARCH METHODOLOGY

In order to find problems, one must become familiar with the way the system operates. To do this, you must first conduct a review of available instructions and manuals. This entails scanning the documents to gain an understanding of how the system is supposed to operate. Only then will empirical observations on site make any sense. Using both the primary and secondary data a mathematical model can be developed to break down the problem into its true nature and the causal relationships that exist.

First, a review of the literature was conducted using related publications and Maintenance Management Manuals. Then, a trip was made to PMTC to conduct interviews and obtain budget documents and budget summaries. This was followed by a trip to Naval Air Systems Command (NAVAIR) Code 418. Finally, a trip to Weapon Station, Concord, and Naval Aviation Depot, Alameda, to observe actual missile maintenance was taken.

D. SCOPE OF RESEARCH

The scope of this thesis will be to determine how intermediate level maintenance is performed for a specific type of ALM. The missile to be used in this study is the Sparrow III AIM-7E/F/M. No attempt will be made to draw similar conclusions for missiles other than for the Pacific Fleet. Nor will any attempt be made to include Foreign Military Sales projects.

E. LIMITATIONS

This thesis will be unclassified. As such, exact missile capabilities, numbers, and readiness figures will not be used.

F. ASSUMPTIONS OF THE RESEARCH QUESTION

The assumptions are:

1. That there will be continued growth in missile inventory.
2. There will be no new breakthroughs in technology.
3. That no new legislation will be passed hindering the Navy from building new facilities, specifically, a ban on constructing new buildings due to environmental impact problems or a change in the maximum amount of ordnance that can be located in a particular location.

G. SUMMARY OF FINDINGS

The longest delay in the maintenance cycle used to be for Guidance and Control sections to go from WEPSTA Concord to Naval Air Depot and return. By developing a rotatable pool of spares, the critical factor is the amount of missiles that can be processed by the WEPSTA. The limiting factors on the processing of missiles are, containers, people, and the test equipment.

The original goal of this thesis was to show cost savings by combining intermediate level and depot level maintenance into a single site located at WEPSTA Concord. However, the research has pointed out otherwise. It not possible for intermediate level maintenance to be performed at Alameda due to explosive limits. It is not practical to move the present D-level facility to Concord.

A cost figure has been developed to show the amount of life cycle costs that can be saved for Sparrow missiles by decreasing maintenance time by a single day.

H. RECOMMENDATIONS

Do not change the present location of the maintenance facilities for either depot or intermediate level activities.

Improve the output of WEPSTA Concord by either increasing container rework, hiring more people, or installing a third test set.

I. CONCLUSIONS

The maintenance of air-launched missiles is a well conceived program that has few problems other than those listed in this paper. Maintenance costs can be accurately predicted by using historical data to determine the amount of maintenance a missile will need and the cost of that maintenance. By following the recommendation made in this study, total costs will decrease with no loss in readiness.

J. ORGANIZATION OF STUDY

Chapter Two will give an overview of the maintenance organization. How the different maintenance levels interact and the work performed at each level will be examined. Finally, a description of the building where the maintenance is conducted and the test equipment used to perform the testing is discussed.

Chapter Three, Analysis, will show what the limiting factors are on the missile maintenance pipeline. A method of determining how to measure the cost of one day of maintenance on total missile inventory will be developed.

In the final chapter, a summary of the information gathered will be emphasized. How and why certain conclusions were reached will be discussed. A list of recommendations in order of priority will also be included.

II. BACKGROUND

The keys to any system are the organizations that support it. First, a breakdown of the organizational relationships and responsibility will be examined. This will be followed by what the Sparrow missile is, what maintenance is performed, and where. A review of the budget process and capability of the the test equipment will finish the section.

A. COMMAND RESPONSIBILITIES

1. The Chief of Naval Operations (CNO)

The Chief of Naval Operations is responsible, under the direction of the Secretary of the Navy for the command of the operating forces of the Navy. As such, he is responsible for the utilization of Naval resources and the operating efficiency of all commands and activities under his command. The CNO is responsible for establishing the Asset Readiness Objective (ARO) for each missile for a particular year. The planning and programming of airborne weapons maintenance workload at shore based maintenance facilities is predicated on the achievement of the CNO ARO published yearly in OPNAVINST C4850 series.

2. Naval Air Systems Command (NAVAIR)

NAVAIR is responsible for the acquisition, quality evaluation and logistic support of all airborne weapons

under NAVAIR cognizance. In addition, NAVAIR provides the technical direction for the manufacture, modification, repair, overhaul, and material effectiveness of their airborne weapons. NAVAIR is also responsible for:

- o Providing the airborne weapons policy guidance.
- o Providing airborne weapons maintenance processing documents outlining maintenance functions, organizations and responsibilities.
- o Assisting in the development of an effective training program for military and civilian personnel assigned maintenance functions.
- o Providing airborne weapons maintenance material allowance lists.
- o Directing the Maintenance Data Collection System (MDCS).
- o Recommending procedural changes, methods and technical guidance to effect continuing improvements in the Naval Airborne Weapons Maintenance Program.
- o Providing technical direction and a centralized system for the control and issue of all technical directives concerning naval airborne weapons and associated material.
- o Maintaining inventory management control of major ALM components and complete ALM's.
- o Ensuring that there is mission planning, facility requirements development, budgeting, funding and the

utilization of personnel, funds, materials, and facilities. [Ref. 1:pp. 1-1-2]

3. Naval Sea Systems Command (NAVSEA)

NAVSEA is responsible to insure that adequate intermediate maintenance facilities are available to accomplish programs under the tasking and direction of NAVAIR. On the Pacific Coast, NAVSEA field activities (WEPSTA Concord and Seal Beach) perform the following functions for NAVAIR in support of NAVAIR in support of the NAWMP (Naval Airborne Weapons Maintenance Program):

- o Receive, inspect, segregate, store, and issue/ship airborne weapons in their assigned missions and tasks.
- o Maintain and rework airborne weapons in accordance with the tasking and direction of NAVAIR.
- o Explosive load, modify, disassemble, assemble and perform tests on airborne weapons.
- o Perform quality assurance on airborne weapons and calibration of NAVAIR test equipment.
- o Report maintenance data via the Applicable MDCS.
- o Make transaction item reporting (TIR) and serial lot item tracking (SLT) to the Conventional Ammunition Integrated Management System (CAIMS).
- o Exercise general supervision of the explosive safety program. [Ref. 1:pp. 1-1-4]

4. Type Commander (TYCOM)

On the Pacific coast, Commander Naval Air Forces, Pacific (COMNAVAIRPAC) under the fleet commander (CINCPACFLT), and Chief of Naval Reserve (CNAVRES), are responsible for the organizational maintenance of airborne weapons assigned them for the operation and support of their naval missions. Specific functions by maintenance level are detailed to subordinate commands. COMNAVAIRPAC is responsible for local coordination of maintenance performed by squadrons/units under their control to ensure effective and economical use of assigned personnel, material, equipment, and facilities.

5. Naval Magazines (NAVMAG)

The NAVMAGs are fleet activities whose responsibilities include weapon receipt, storage, and issue. They are located at: Subic Bay, RP; Seal Beach, CA; Concord, CA; Guam, Mariana; Lualuale, HI.

6. Pacific Missile Test Center (PACMISTESTCEN)

The Pacific Missile Test Center is assigned as the cognizant maintenance engineering activity for ALMs and is responsible for maintenance management functions such as workload coordination: planning, monitoring, and execution, inventory coordination, and program support activities. PACMISTESTCEN responsibilities are implemented within its own command structure and through the employment of detachments at the weapon stations.

7. Mobile Maintenance Unit-One (MMU-1)

MMU-1 is located at Cubi Point, The Republic of the Philippines. They perform intermediate level maintenance on air launched missiles. They are not within the NAVSEA claimancy like the other I-level activities. Rather, they work for CINCPACFLT under the direction of COMNAVAIRPAC. Their workforce is composed of U.S. Navy sailors and Philippine nationals. There are two PMTC representatives there to keep the test equipment operational, to do pre-sentencing work for returning carriers and ammunition ships, and to provide training and technical assistance.

8. Naval Weapon Station (WEPSTA)

The Naval Weapon Stations are responsible for performing I-level maintenance on ALM's. They are set up as NAVSEA controlled Naval Industrial Fund (NIF) activities. The NIF is a revolving fund used to finance commercial or industrial type Naval activities, such as WEPSTAs. Major charges to the fund are civilian labor, material purchases, travel, transport of material, and contract services. The fund is reimbursed through the sale of materials and services performed for the contracting activity. The customer is charged for all labor performed and the materials procured through this account. [Ref. 2:pp. 1-18]

They are not true NIF activities in that a pure NIF activity will bid on a job and their cost will not change throughout the year. Any profit or loss was kept by that

activity. In this case, if there is a shortage NAVSEA can go back to NAVAIR and request additional funds. The reverse is also true, if there is a profit NAVSEA will refund a portion of the excess to NAVAIR. The Weapons Stations within the Pacific Fleet are Concord, CA, Seal Beach, CA.

9. Weapons Quality Engineering Center

The WQECs are departments within the WEPSTAs, Naval Weapon Support Center, and Naval Ordnance Station. They are responsible for monitoring the quality of maintenance and failure analysis. This provides an assessment of weapons and component stockpiles readiness.

10. Metrology Engineering Center

The Metrology Engineering Center, Naval Weapons Station Seal Beach, Pomona Annex is responsible for the developing, reviewing, and approving calibration for Test Equipment. They are also responsible for assigning and maintaining calibration intervals to ensure currency.

B. THE SPARROW MISSILE

1. Sparrow

According to Jane's WEAPON SYSTEMS, "Sparrow is a medium-range, all weather, all-aspect, semi-active guided missile that is compatible with both Continuous Wave and pulse Doppler illuminations." [Ref. 3:pp. 760] In addition to the air launched variety used in this study, there is also a surface launched version, RIM (series). The current production model is the fifth in a series.

The missile has a cylindrical body 8 inches in diameter and approximately 12 feet in length, with a wingspan of 40 inches. It weighs approximately 510 pounds. The missile consists of three major sections: guidance and control, warhead, and rocket motor. The AIM-7E versions (Figure 1) has a target seeker group and flight control group which are assembled as a single group at the front of the missile.

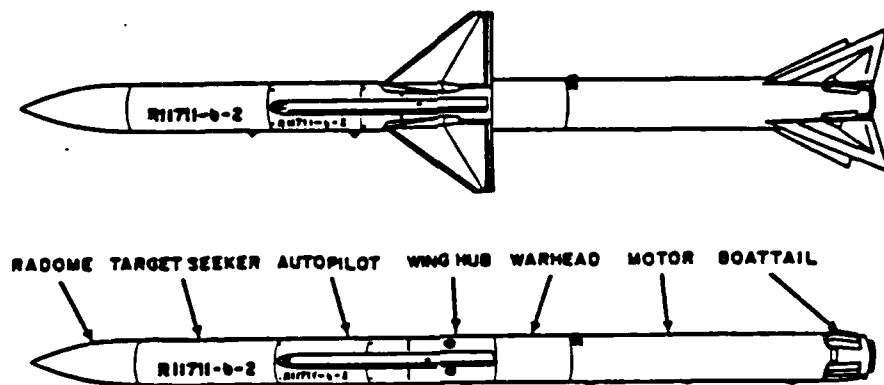


Figure 1

SPARROW AIM-7E

The AIM-7F/M version (Figure 2) is different. It has a target seeker group and a flight control group which are

physically separated by the warhead. [Ref. 4:pp. 3-1]
 These two groups are referred to as the Guidance and Control (G&C).

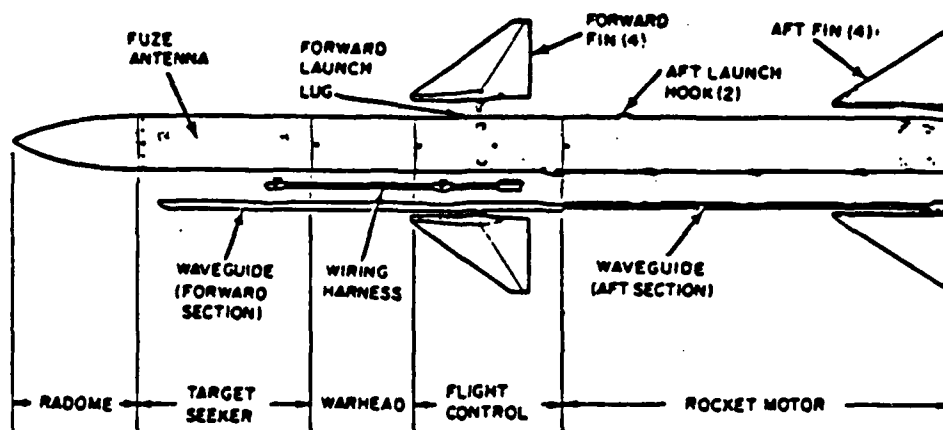


Figure 2
 SPARROW AIM-7M

While the missile will be referred to as an ALL Up Round, in reality it is not. For, by definition, a AUR needs no assembly while the air version of the Sparrow requires the addition of its wings. There are four movable wings attached to the flight control group to provide for missile flight path control in pitch, roll, and yaw planes.

There are four stationary wings attached to the rocket motor to provide stability during flight.

The RIM series (surface launched version) is exteriorly different in that it has folding wings forward and clipped wings aft (Figure 3).

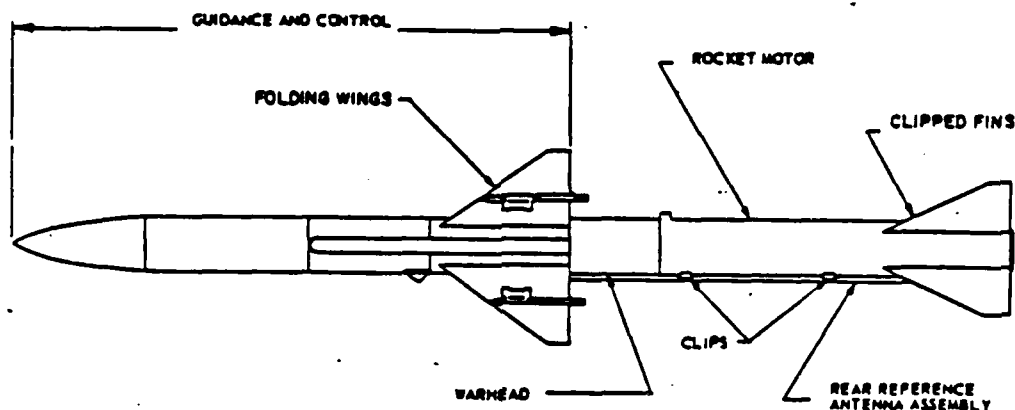


Figure 3
SPARROW RIM-7H

C. MAINTENANCE PROGRAM

Under the All Up Round concept, shipboard and NAS organizational maintenance functions are kept to a minimum.

The objectives of the ALM program are to provide to the operating forces with their required allowance of ready-for-issue (RFI) all-up-round (AUR) missiles, often called a wooden round, to meet the Chief of Naval Operations (CNO) Asset Readiness Objectives (ARO) for operational and war reserve stocks, to improve ALM operational capabilities while at the same time

reducing the maintenance burden, and to achieve this effectiveness in the most efficient and cost effective manner. [Ref. 2:pp. 1-1]

The missile maintenance program begins with the procurement of the missile from a vendor, assembly at the WEPSTA, issue to the fleet, and return to an I-level activity for maintenance.

1. Procurement and Assembly

Upon NAVAIR acquisition of AUR's and ALM sections from the vendor, the AUR's/sections are shipped to a designated WEPSTA for testing and or assembly. Sections successfully meeting test requirements are available for assembly into a AUR. Upon completion of assembly, the AUR is stored until needed or is issued to the fleet.

2. Fleet Issue

AURs are provided to the carriers from the weapon stations RFI stocks. The missiles are generally loaded on board a service force ship and transported to the carrier where they transferred during Underway Replenishment (UNREP) and stored in magazines in their AUR containers. During a deployment, the carrier only unpacks a small percentage of missiles, depending on the current threat or training exercises.

The fleet is responsible ensuring the maximum use of each missiles Serviceable In Service Time (SIST). This is more difficult than it seems since the missiles are

stored in a magazine with no way to access a container in the back for issue without moving every container in the magazine.

During a deployment, the ship should keep as many missiles as possible in deep stowage, in their containers seal unbroken, withdrawing only those necessary to meet operational commitments.

Deep stowage assets are missiles or components stored in environmentally protected containers since their last WEPSTA processing. Only those missile that have remained in deep stowage are normally eligible for cross-decking. Once a missile has been taken out of its container or the lead seals broken the receiving ships Ordnance Officer will normally refuse to accept it. Unless, of course, operational necessity requires otherwise.

A missile that is loaded onto an aircraft and flown without being fired is considered to have been captive carried. Missiles that are captive flown require more maintenance than those missiles that have remained in deep stowage. Their internal components have been energized and the acceleration/deceleration involved in launch and recovery of the aircraft places a great deal of stress on the components. Due to the inherent wear received by the missile in loading, unloading, and flying through bad weather, a missile may not look fine yet be fully functional. Pilots used to request another missile, a new

"better looking" one. Recent direction by the fleet commander require that once captive flown, a missile should be continued to be used in that capacity until a failure is detected.

Redistribution is usually accomplished via cross-decking procedures. By cross-decking, the cargo of one ship is transferred to another ship. Cross-decking is repeated throughout the SIST period whenever practicable until it becomes necessary to return the missiles to Continental United States (CONUS) in accordance with Maintenance Due Date (MDD) requirements. The cross-decking of serviceable missiles contributes to the asset readiness.

3. Maintenance Pipeline

Fleet return missiles enter the pipeline by either passing their MDD, exceeding their allowable captive flight hours, or being damaged. Sixty days prior to completion of a deployment, a presentencing team is sent to the Aircraft Carrier (CV) to determine the exact status of the missiles. The team is composed of technicians from PMTC. The missile are inspected and broken into two categories, those to be cross-decked to another CV or Ammunition/Fast Combat Stores Ship (AE/AOE), or transferred to the weapon station. Upon arrival at the weapon station, the missiles are stored in bunkers or railroad flat cars until they are scheduled for the production floor. The missile is taken out of its container, inspected, tested and if without fault, repacked

with a new MDD. If the missile fails, the faulty section is identified and replaced.

A missile could "fail" while on deployment in the Indian Ocean, be transported by ship, transferred to a WEPSTA and finally inspected. During the inspection, it could be determined that the missile needed no maintenance at all, merely that it needed to be inspected to have its MDD updated.

Based on historical and predicted failure rates the WEPSTA is able to forecast failure rates. This allows them to budget and order spare parts accordingly. Table 1 is an excerpt showing predicted failure and anticipated jobs required for FY88.

The time required to do the actual test on a missile is 60 minutes for an AIM-7M, 70 minutes for an AIM-7E, and approximately 80 minutes for an AIM-7F [Ref. 5].

The most critical component is the Guidance and Control sections. If that part fails and is in need of repair, the section is shipped from WEPSTA Concord to Naval Supply Center (NSC) Oakland. The parts remain there until Naval Aviation Depot (NADEP) Alameda has the availability to begin work on Sparrow G&Cs. Upon being reworked, the G&Cs are returned to NSC Oakland. If Concord is in need of a new G&C, they must requisition a G&C (new or reworked) from NSC Oakland

Assets on hand in the maintenance pipeline include both All Up Rounds and individual components comprising the AUR.

TABLE 1
AIM-7F OCCURRENCE FACTORS FOR FY 88

<u>Job Description</u>	<u>Occurrence Factor</u>
AUR Inspection and Test	1.00
AUR Retest	.22
AUR Disassembly	.33.
AUR Container Replacement	.17
G&C Replacement	.22
Warhead Replacement	.03
Warhead WQEC X-RAY	.01
Rocket Motor Replacement	.08
Rocket Motor WQEC X-RAY	.01
AUR Assembly	.33

Essentially, until AUR assembly occurs, the maintenance pipeline consists primarily of individual missile system components. Components in an unserviceable condition constitute the maintenance backlog at each

Intermediate Level Activity (IMA) and Designated Overhaul Point (DOP).

D. MAINTENANCE LEVELS

1. Organizational Level Maintenance

Organizational maintenance consists of those functions normally performed by the operating units on a day-to-day basis in support of their own operations. This maintenance is normally performed by weapons personnel assigned to the maintenance department of a naval station or squadron. The only missile testing done at the organizational level utilizes the test equipment built into the aircraft. While on the ground, the aircrew is unable to tell if the missile is fully operational. They must be airborne, with the radar energized to determine if the seeker head is functional. The O-level Maintenance consists of:

- o Inspect AUR containers/ cradles, stow.
- o Inspect, stow external parts.
- o Clean missile and external parts as required.
- o Retorque body joint clamps as required.
- o Install/remove wings/fins/external parts.
- o Load/download missile on/from aircraft.
- o Perform missile on aircraft test(s) and built in test(s) as required.
- o Perform missile preflight /postflight inspection.

- o Replace in container.
 - o Containers/cradles--Desiccant replacement only.
- [Ref. 1:pp 3-1-3]

2. Intermediate Level Maintenance

I-level maintenance is the responsibility of, and performed by WEPSTA and MMU. This level of maintenance consists of testing AUR and section replacement. In addition the I-level is responsible for:

- o G&C/MGS-Inspect, test, section removal/replacement, external and selected internal components replacement only.
- o Rocket Motor/Sustainer. Inspect, test, replace. Selected igniter replacement authorized.
- o Warhead/S&A Device-Inspect, replace certain components only.
- o Electronic firing switch, Fuses/Target Detonation Device (TDD)--Inspect, test, replace.
- o Wings and Fins--Inspect, repair, replace only.
- o Containers/Cradles--Minor part replacement, repair, clean.
- o Selected IMA's are authorized ALM assembly or disassembly.
- o AUR inspection and test.
- o Remove AUR and reinstall into container.

[Ref. 1:pp. 3-1-3]

The missile is taken out of its container with a sling and put into a moveable cradle. The missile is then immediately hooked to a missile ground. A missile ground is similar to an electrical ground but it is another system, suspended from the ceiling. A missile must always be hooked to it except when they are in transit within the building. The missile is first visually inspected, then taken to a test cell. After being hooked up, the cell is evacuated and the heavy door shut. The missile test is run from another room with the progress monitored by the computer operated test equipment. The missile can be observed by a stationary camera to ensure that no wires have come loose. After successful completion, the missile is removed from the cell, cleaned up, and put into a container.

The I-level maintenance for the rocket motors in Concord consists of visual inspections, cosmetic repairs, and a check of the igniter circuit.

The I-level maintenance of the warhead consists of a visual inspection. If damage is suspected, the warhead can be transported to the WQEC building and X-rayed.

3. Depot Level Maintenance

Depot level maintenance is performed on airborne weapon sections, not on AURs. It include the overhaul and complete rebuilding of assemblies, subassemblies, and end user parts. They support the other maintenance activities by providing repaired parts and technical expertise.

Depot level maintenance of each missile combined will normally be limited to repairs where the cost of labor does not exceed 65% of new procurement costs. This percentage factor does not apply to items that are considered critical or in the best interest of the government. [Ref. 1:pp. 3-4-1].

They are also responsible for the maintenance of the test equipment used at the I-level. D-level work consists of:

- o G&C/MGS--Inspect, test, repair, rework, modify to assembly/subassembly/component level. Reassemble, perform final system test.
- o Rocket motor/Igniter/Gas Generators- Repair, rework, regrain, replace, modify.
- o Warhead/S&A Device/Electronic firing Switch--Repair, rework, replace, modify.
- o Fuze/TDD-Repair, rework, modify.
- o Ordnance Section /Fuze Components- Repair, rework, modify.
- o Wings and Fins--Repair, rework, modify.
- o Rear Antenna--Repair.
- o Container/Cradles--Major repairs. [Ref. 1:pp 3-1-3]

Naval Aviation Depot is located at NAS Alameda. They perform D-level maintenance on Phoenix, Shrike, and Sparrow missiles. They are the only facility to perform this maintenance. The building was built in 1972 and contains 80,000 square feet, with the east wall designed to be knocked out for future expansion. They also perform

TABLE 2
MAINTENANCE BREAKDOWN SUMMARY

ACTIVITY CV, NAS, MAG, NAVSTA	LEVEL OF RESPONSIBILITY ORGANIZATIONAL LEVEL MAINTENANCE
MMU-1, SUBIC BAY	I-LEVEL FOR AUR
WPNSTA CONCORD	I-LEVEL FOR AUR D-LEVEL FOR WINGS, FINS, CONTAINERS
WPNSTA YORKTOWN	I-LEVEL FOR AUR D-LEVEL FOR WINGS, FINS, CONTAINERS
NAD ALAMEDA	D-LEVEL FOR G&C
RAYTHEON/GENERAL DYNAMICS (CONTRACTOR)	D-LEVEL FOR G&C
NAVWEPSUPPCEN, CRANE	D-LEVEL FOR WARHEADS
NAVORDSTA, INDIAN HEAD	D-LEVEL FOR ROCKET MOTORS, GAS GENERATORS
WQEC CONCORD	QUALITY EVALUATION FAILURE VERIFICATION AND ANALYSIS OF G&C, WARHEAD, WINGS, AND FINS
WQEC YORKTOWN	QUALITY EVALUATION FAILURE VERIFICATION AND ANALYSIS OF G&C
WQEC CRANE	QUALITY EVALUATION FAILURE VERIFICATION AND ANALYSIS OF S&A AND ELECTRONIC FIRING SWITCH
WQEC INDIAN HEAD	QUALITY EVALUATION OF ROCKET MOTORS, IGNITERS, AND GAS GENERATORS
MEC POMONA	CALIBRATION INTERVAL ANALYSIS OF TEST EQUIPMENT

maintenance for Air Force missiles, including the D-level work for their fins and wings. They presently have seven AN/DPM-22 missile test set, miscellaneous hydraulic test equipment for AIM-7E and AIM-7F, pneumatic test equipment for AIM-7M, paint booths, an anechoic testing chamber and a stripping facility. According to the plant superintendent they are capable of doing 95% of all work within the building. The remaining work, bead blasting and special stripping, is done in a nearby building. They even have the capability to do polyurethane painting. The employees are predominantly WG-11/12, consisting of two trades, Ordnance Equipment Mechanic and Electronics Mechanic. [Ref. 6]

The facility may be impressive but what is even more impressive is the impression one gets while walking through the production floor. It is apparent that the workers take pride in their work and have a dedication to the task at hand. This is not production line work with the workers performing the same task each time. Every missile component has its own problems and it is a challenge to trouble shoot and repair them. The management of NADEP Alameda should be commended for retaining their employees when they could make more money working in Sunnyvale for an electronics company. .

The NADEP used to have a 4 year apprenticeship program that would bring someone with no training into the program and prepare them for an entry level position at

NADEP, a WG-8 position. After obtaining an entry level position, it takes a worker five years to reach WG-11, and if able to perform well enough reach WG-12 in three or four additional years. The average time working at NADEP is sixteen years.

The following is a summary breakdown of maintenance performed at each activity.

E. TEST EQUIPMENT

The heart of any maintenance program is its test equipment. Unless your equipment is accurate, you are subject to false accepts/rejects. The result of a false accept could be the loss of aircrews. The I-level tests, particularly the AN/DPM-156 is only capable of testing a Go, No-Go situation. They only know if the missile is capable of being launched and the rocket motor firing, not if the missile is capable of operating at the edges of its envelope.

1. AN/DPM-21

The AN/DPM-21 is the test set used by WEPSTA to perform I-level tests. After being hooked up and the test sequence initiated by the operator, the missile is automatically tested using a built in microcomputer module. The test will continue until completion or a fault is discovered. The operator then can either reset the test to continue or stop the test. If the operator does nothing,

the machine will automatically resume testing after two minutes. Upon completion of the test, a Go or No-Go indication will be given. A printer provides a hardcopy for the record. The missile is provided operational stimuli by generated electrical and Radio Frequency inputs to the target seeker and flight control group. The missile responds by routing test results to the test set. The results are compared with specified parameters. The missile test is automatically monitored in an adjacent room by test personnel. Replacement cost would be approximately 7.5 million dollars. The test equipment is hard to maintain and spare parts are virtually non-existent.

2. AN/DSM-156 Guided Missile Test Set

The AN/DSM-156 is used to perform intermediate level operational tests on Sparrow Missiles. The unit can be broken down into three transportable shipping cases, which when combined with a Guided Missile Cradle is all that is necessary to perform the test. The AN/DSM-156 is a variant of the Air Force AN/DSM-151 Test Set. The major difference being that the Navy version is designed to be operated from a remote location. This allows the missile to be tested as an AUR. The Air Force Version must be disassembled prior to test.

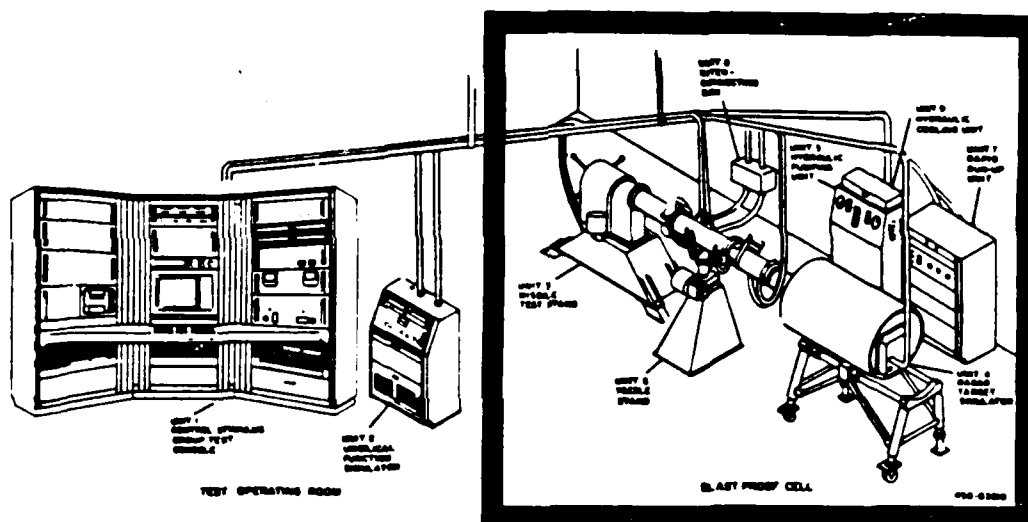


Figure 4
AN/DPM-21 Guided Missile Test Set

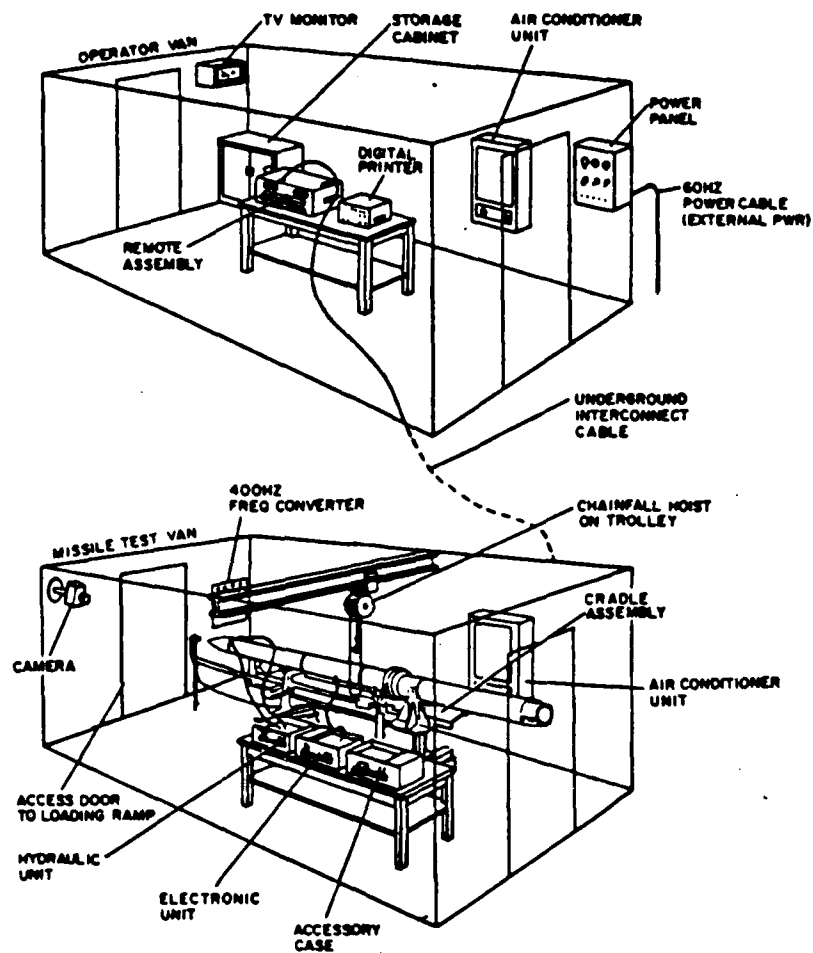


Figure 5
AN/DSM-156 Guided Missile Test Set

The AN/DSM-156 can be housed in two separate vans to form a Mobile Missile Maintenance Facility. In May 1982, such a unit was set up in Subic Bay, Republic of the Philippines. It is operated by Mobile Maintenance Unit-One. The unit is composed of active duty sailors and Filipino Nationals. There are also two PACMISTESTCEN employees who are responsible for maintaining the test equipment.

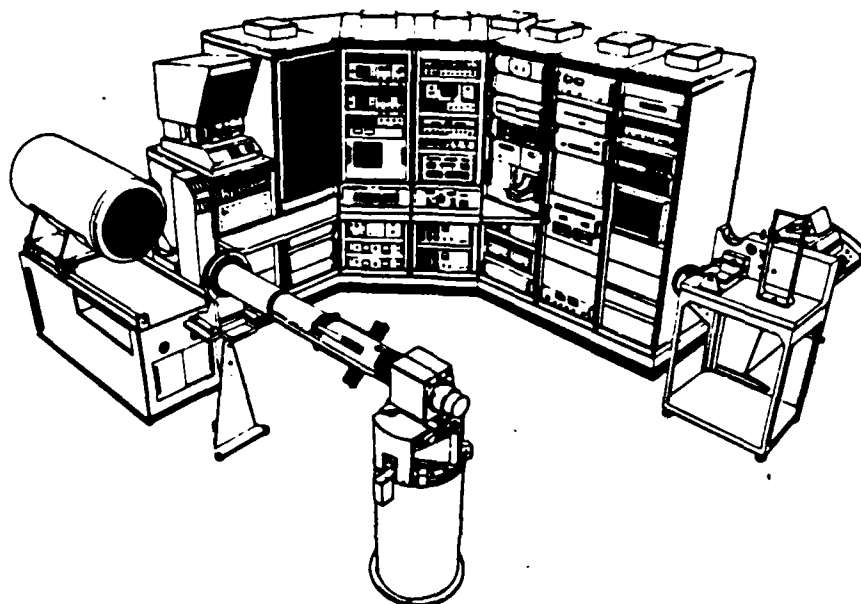
3. AN/DPM-22A Guided Missile Test Set

The AN/DPM-22A test set is used by NADEP Alameda to perform D-level tests on Sparrow missiles. The set has three different configurations; target seeker group, flight control group, and Missile Guidance Set (MGS). It is more diagnostic in nature than the AN/DPM-21 and is capable of isolating a fault down to the work replaceable assembly. The AN/DPM-21 is computer controlled to do all test routines as well as doing a logic analysis of the test results to automatically isolate the highest failure rate item, which guides in isolating the more difficult repairs.

Currently NADEP Alameda has seven test sets to do D-level maintenance on AIM-7E/F, with six additional sets to be installed to test AIM-7M.

F. MAINTENANCE COSTS

The cost for performing Sparrow maintenance is straightforward. The WEPSTA is given an estimate of the number of missiles to be processed for that year. By using



AN/DPM-22A Guided Missile Test Set

Figure 6

the occurrence factors, shown earlier, they can predict the amount of work by category. They then use the Industrial Processing Guide to determine the number of direct labor hour necessary to perform those tasks. Then multiplying those figures by their standard labor rate they come up with totals for the year. These bids are then sent to and reviewed by PMTC.

TABLE 3
AIM-7F MAINTENANCE COSTS FOR FY 88

TASK DESCRIPTION	COST in \$
<u>I-LEVEL MAINTENANCE</u>	940
AUR to RFI	
<u>COMPONENT COST</u>	
Missile Sentencing Inspection	72
AUR Disassembly	203
Warhead Repair	185
Rocket Motor Repair	400
Wing and Fin Set	179
D-LEVEL	
Guidance & Control Repair	9,995

Costs are broken down by either performing the simple inspection, AUR to RFI, or the cost to perform a specific task. The WEPSTA is paid only for completed units whereas the depot facilities are paid for the number of units inducted.

III. ANALYSIS

A. THROUGHPUT CAPABILITY

Estimating ALM throughput capability is influenced by a number of variables such as manpower levels, skill mix, new production/Fleet return workload planning, test cell and test equipment availability and certification, support equipment availability, personnel training, asset and material availability, storage capability, and facility constraints [Ref. 7:pp. 4]. In some facilities there is the additional constraint of the type and total quantity of missiles that are being worked on.

TABLE 4
WEPSTA CONCORD SPARROW CAPACITY

FLEET RETURN	NEW PRODUCTION	
TWO TEST CELLS	1500	3000
THREE TEST CELLS	2250	4500

The quantities listed below are for the estimated number of missiles to be processed annually by WEPSTA Concord working one eight hour shift, five days a week.

The throughput quantity is the maximum amount of missiles that could be processed if that was the only missile to be worked on. New production capability is based on 12 missiles per day. Fleet Return quantity is based on completion of six AUR to RFI missiles per day.

TABLE 5
INTERMEDIATE LEVEL WORKLOAD PROJECTIONS
FOR WEPSTA CONCORD

TYPE					
<u>AIR</u>	FY 88	FY 89	FY 90	FY 91	FY 92
AIM-7F	187	210	144	137	78
AIM-7M (FR)	278	733	991	1220	12342
AIM-7M (NEW)	844	660	349	0	0
SUBTOTAL	1309	1603	1484	1375	1312
 <u>SURFACE</u>					
RIM-7H (FR)	125	81	86	71	0
RIM-7M (FR)	198	248	261	304	286
RIM-7M (NEW)	175	120	63	0	0
SUBTOTAL	498	449	410	375	286
 TOTAL	1807	2052	1894	1732	1598

At present WEPSTA Concord has only two test sets. A third test set is being transferred from the Fallbrook Annex and should be operational by the beginning of the fourth quarter FY88.

The original thrust of this thesis was to show that the Navy could decrease turnaround time and become more cost effective by combining intermediate and depot level maintenance into a single site. An analysis of the actual maintenance process shows that this is not feasible. What will follow are the reasons for that conclusion, and what the next best choice is.

TABLE 6
ESTIMATED PERCENTAGE OF CAPACITY FOR WEPSTA CONCORD
IN USE BY FY

	FY 88	FY 89	FY90	FY 91	FY92
AVERAGE	62.9	73.9	75.0	76.9	71.0

As was shown in the data section, there is an average 175 day turn around time for the critical part of G&C. By knowing this amount, the planners figure on the amount of missiles needed in the total inventory to support current

needs and still have missiles tied up in the maintenance pipeline. This is all taken into account when developing the Logistics Support Plan. Given the current 175 day turn around, that would mean that a missile would have a maximum of 63% Asset Readiness (AR). This means if they need 6,300 missiles available, they must procure 10,000 missiles. Realizing this, the Navy was faced with a problem, how to decrease the delay time associated with G&C repair. Otherwise, missiles would be tied up in Concord awaiting the G&C to be repaired in Alameda. The reason the Navy could not just go out and purchase more G&C only is that since it is considered the critical part, for every G&C the Navy purchased it was considered to have bought an additional missile. After receiving permission from SECNAV, the Navy was able to establish a rotatable pool of spares that would not count against their AR. This resulted in a dramatic increase in maximum AR since the critical time is now the time it takes to perform intermediate level maintenance at Concord. The new maximum theoretical AR is 92% given a 25 day turnaround in maintenance.

Since Concord averaged a 26 day turnaround instead of the 25 day standard, this has a direct impact in the total number of missiles available, basically a total of 28 missiles in the total inventory per day.

Requirements to do D-level maintenance for Navy Sparrow missiles has been estimated at 4,000 sq ft and 15 people [Ref. 5]. However, this would not include the maintenance of the skins or hydraulics/pneumatics. In order to do all Sparrow work, including Air Force/FMS birds an activity in Concord would need a 20,000 square feet building and a staff of 40 people. Since the experienced people presently work in Alameda, transfer costs would have to be figured in. The cost is insignificant since the distance is only 35 miles. The equipment as well as the people to operate this specialized equipment would have to be transferred. Since G&C are no longer a limiting factor, there is no reason for the D-Level activity to be moved. If they were, the following points need to be considered.

1. The cost in AR due to the stoppage of maintenance while tearing out test equipment, packaging and installing the equipment at Concord.
2. Time must be allowed for troubleshooting and calibrating the equipment after the move.

B. FACILITIES AT NAVAL WEAPON STATION CONCORD

1. Building 87

Intermediate level repairs are being conducted in Building 87 (Figure 7). The building was built in 1959. It is a one story concrete building enclosing 22,703 square feet. The building is broken into two sections; the A

section is used to conduct the maintenance of the AUR' while the B section is used as storage and uncrating of sections. The actual test cell have eight foot thick walls and blast door to relieve pressure in the event of an explosion.

2. Building 97

Presently, intermediate level repair for Sparrow rocket motors and warheads is being done in Building 97 WEPSTA Concord. The building is a one story, steel frame building with 13,832 square feet. It is considered substandard, but functionally adequate.

Substandard describes a facility with modification or repair deficiencies that normal require approval and funding beyond the authority of the activity commanding officer to make the facility adequate for its function. [Ref. 7:pp. 16]

The building is programmed under MILCON project P-271 in FY 90 to upgrade the building to accept STANDARD and TOMAHAWK work.

C. TIME STANDARDS

The CNO has developed standard times it should take for different phases of the maintenance cycle. These standards are a result of the Weapon System Planning Document, Fleet Analysis Center Performance Monitoring System, and experience with earlier SPARROW versions. These figures do not take into account the time a missile is in transit to CONUS.

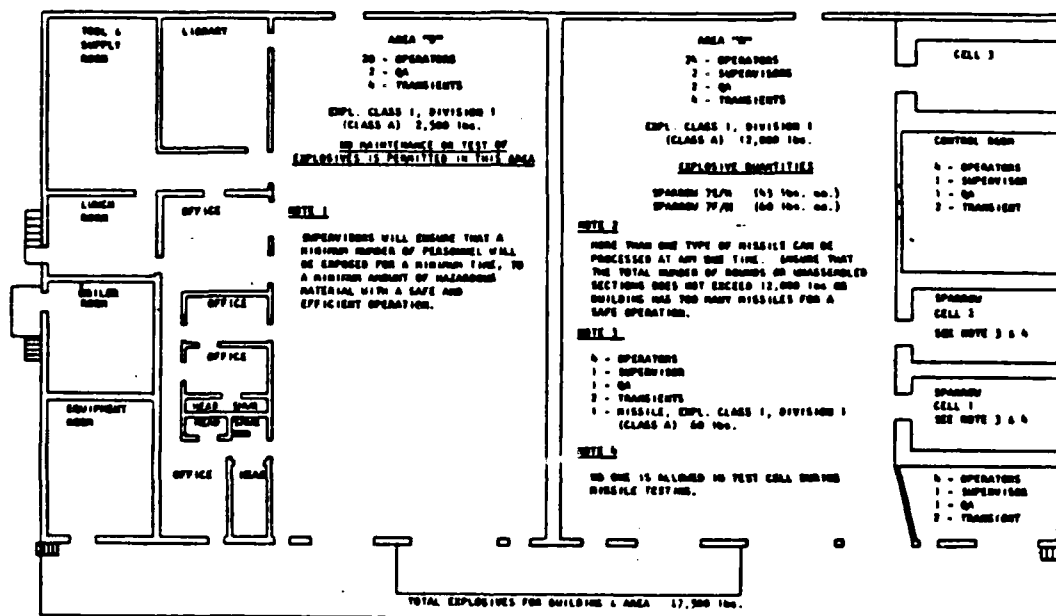


Figure 7
 Building 87 WEPSTA CONCORD

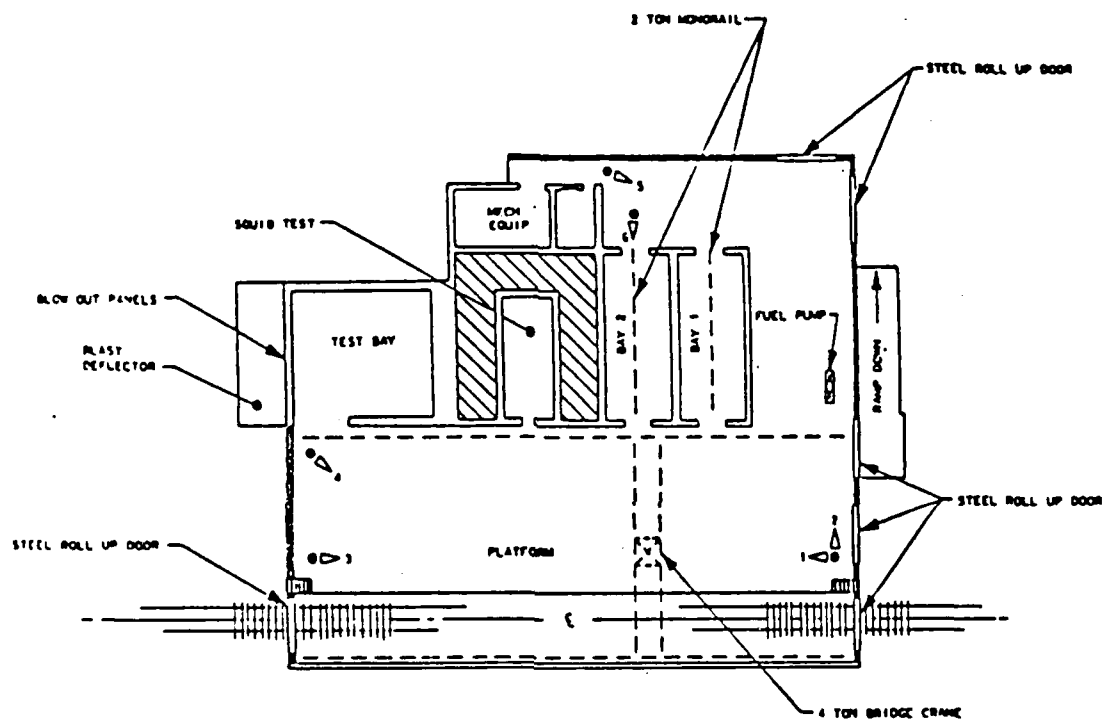


Figure 8
Building 97 WEPSTA CONCORD

The Asset Readiness is determined by the number of missiles in a All Up Round (AUR) status divided by the total number of missiles in the inventory, or the asset objective, whichever is lower. The Asset Readiness Objective is the goal to be achieved/maintained in asset readiness percentage. An improvement in Asset Readiness is achieved by ensuring that adequate quantities of unserviceable weapons in the maintenance pipeline are converted to a serviceable condition.

By decreasing the number of days to process, the missiles will yield a higher ARO as well as decrease the total amount of missiles needed in the inventory.

TABLE 7
MAINTENANCE DELAY STANDARDS

<u>ELEMENT</u>	<u>STD DAYS</u>	<u>AVERAGE</u>
AWAITING TEST/INDUCTION	15	16
TIME IN MAINTENANCE (NWS)	10	11
AWAITING WQEC INDUCTION	15	14
WQEC TEST VERIFICATION	10	9
AWAITING DOP SHIPMENT.	10	12
TRANSIT TIME/AWAITING DOP INDUCTION	60	56
TIME IN MAINTENANCE	30	29
AWAITING TRANSIT/TRANSIT TO NWS	<u>25</u>	<u>25</u>
TOTAL TURN AROUND TIME	175	172

The above figures were derived from data for the first six months of 1985.

The SPARROW maintenance time clock begins when the missiles, in their containers, arrive at the pier. If they are in any other port but Concord, they must first be shipped to Concord via rail or truck. Once at Concord, they are stored in rail cars or magazines until they are taken to Building 87.

The Navy was hiring to payroll but this program has been overridden by a hiring freeze. The addition of more people could solve their backlog problem. To solve their problem, they can use flex hour to alleviate the problem. The other solution is to hire/start a second shift. This will give you more access to the test equipment.

D. MISSILE AVAILABILITY

The amount of time a missile is available is a function of its maintenance time and the time it is available for fleet use. By using this information the amount of missiles to be procured to meet the threat can be determined. For example, if a missile is available for use 84% of the time and 840 missiles were needed to handle current needs, a total of 1,000 missiles would be needed. Given that the SIST for SPARROW missiles is 300 days it is easy to see that the Navy dramatically changed the missile availability by developing the rotatable pool of G&C. They changed the

turn around time for the missile from 175 days to 25 days. Turn around time is the time it takes for a missile to enter the maintenance pipeline and return to an operational status. This time includes transportation, maintenance, and time waiting to do the next event.

$$\begin{aligned} \text{Missile Availability} &= \frac{\text{SIST}}{\text{Turn around time} + \text{SIST}} \\ \text{Old Missile Availability} &= \frac{300}{175 + 300} = 63.16\% \\ \text{New Missile Availability} &= \frac{300}{25 + 300} = 92.31\% \end{aligned}$$

If you were to take one day out of the maintenance cycle. Potential availability for the missile will increase.

$$\text{Potential Missile Availability} = \frac{300}{24 + 300} = 92.59\%$$

Assuming that 9,231 missile were needed to handle current operational requirements, 10,000 missiles will need to be procured. Taking 1 day out of the maintenance cycle will make 9,259 missiles available on any given day. So, instead of increasing asset readiness it is possible to procure less missiles and have the same readiness that there was before the change.

92.31% of 10,000 missiles = 9,231 missiles

92.59% of 10,000 missiles = 9,259 missiles

9,259 - 9,231 = 28 missiles

Potential Procurement Cost Saving

28 missiles @ \$192.500 = \$5,390,000

A cost savings in procurement costs of \$5,390,000 can be realized if one day was cut in the maintenance cycle, provided the cost of that saving was free. A list of alternatives can be developed, such as, hire more personnel, pay overtime, purchase more test equipment. Then the cost of these alternatives can be compared to the savings realized by cutting the maintenance time. Those alternatives the cost less to implement than the price of one day of maintenance need to be explored.

E. MISSILE CONTAINERS

The other problem is that of containers. They are designed to carry three AIM-7 missiles, less fins. They are designed to be waterproof but not airtight. This results in

humidity being trapped inside when it is first packaged and while it is in storage. As the container goes from a warm environment to a colder one, water condenses inside the container. This causes the attached humidity indicator to change colors, indicating excessive moisture, a problem serious enough to require that enclosed missiles be inspected. The O-level activity has no way of checking if the container failed or the missiles did.

IV. SUMMARY, CONCLUSIONS, RECOMMENDATIONS

A. SUMMARY

Maintenance is performed for one of two reasons, either preventative or corrective. The Navy performs preventative maintenance by checking the missile every thirty months to ensure it is still operational. Corrective maintenance is also performed to correct damage or replace a failed part. For most equipment it is simple to find out if it works, simply turn it on. Unfortunately, the only sure way to find out if a missile works is to fire it. Since this is not possible, the present maintenance program has been made. It works. They have in excess of a 94% success rate with live firing. It is easy to say increase the MDD to achieve cost savings but this would be foolish if it impacts readiness.

This thesis has shown how SPARROW missile maintenance is organized, performed, and the costs involved. The key to the maintenance pipeline is the capacity of the WEPSTA to process missiles.

B. CONCLUSIONS

The maintenance program for SPARROW missiles works. The proposal to combine depot and intermediate level into a single site is without merit. To do this would require duplicating the work presently being done at one site at

the other. This should not be done. If the work currently being done in Concord were to be shifted to Alameda, the explosive limits for the base will be exceeded. This is because the missile must be fully armed during an I-level test with an AN/DPM-21.

The other alternative is to build a D-level facility at Concord. If you wanted to do Navy missiles, that would mean duplicating work that is done only 25 miles away. If you wanted to build a facility to do all missiles, including Air Force missiles, the costs are substantial. But there would be no benefit that would be realized. This is because the rotatable pool of G&C sections takes the time element of repair of G&C out of the picture. There is inefficiency in the way G&C are transferred back and forth from Alameda and Concord, but it has no impact on G&C availability.

Since combining the two activities is not a realistic alternative, procedures to decrease the amount of time needed to do maintenance at the Weapon Station need to be found. In the following section, three alternatives will be discussed.

C. RECOMMENDATIONS

As was shown in the Analysis Chapter, the cost avoidance for decreasing one day of maintenance is \$5,390,000. To accomplish this you must make the system more efficient. Prior to the establishment of the rotatable

pool for G&C, the most critical factor was the turnaround time for the G&C. This meant that the best ARO you could hope for was 63%. With the establishment of the pool, this number improved to 92%. This does not include the time the missiles are in transit to CONUS. At present there are three main factors slowing down turnaround time. They are missile containers, number of personnel, and test equipment. Each item will be discussed separately.

The weapon station had, on 1 December 1987, enough parts to assemble 600 missiles, yet only the containers for 150. The problems with the containers seem chronic, yet no action has been taken. Either new containers need to be developed or the storage/packing of the containers will have to be kept in a controlled environment. The problem must be given precedence in order for the SPARROW program to remain successful.

WEPSTA Concord ability to handle missiles is reaching its capacity. It is not possible to simply add people in an attempt to handle the workload. The working area has limits as to the maximum number of people allowed on the production floor at any single time. The amount of missiles that can be processed is limited by the number of test sets and not the number of people. Possible solutions are to go to flexible hours or a small second shift. This would allow for more missiles to have access to the test set than would be possible in a regular eight hour shift.

The third test set must be installed and made operational. The time to complete a test for a single missile is approximately one hour if everything goes well. However, if a fault is detected, or problems develop, this could cause a missile to be tested a number of times before passing inspection. Combine this with a single shift the amount of missiles that can be processed each day remains small.

The following recommendations will not increase Asset Readiness but are worthy of mention.

Develop a procedure to notify the entire missile maintenance pipeline of changes in the workload schedules. This could best be accomplished by the presentencing team which only notifies PMTC and NAVAIR of the missiles that need maintenance. No similar notice is given to NAVSEA which has to schedule the actual maintenance. Nor is notification given to the NADEP in Alameda on how many G&C to expect and when. Due to the high degree of confidence in what repairs will be required, everyone could benefit from this advance knowledge and could plan accordingly.

A contingency plan to test SPARROW missiles in forward areas needs to be developed. Since it is considered too hazardous to test the missiles aboard ship, a mobile self contained test facility is needed. It is recommended that a second set of vans similar to the one used by MMU-1 be procured and wherever there is a high operating environment

that the vans be forward deployed. This would allow the fleet to have expired missiles returned almost immediately. If spare G&C sections were also sent this would allow for an even quicker reissue.

Allow NAD Alameda to mix Guidance sections and Control sections. Presently they must keep the two sections as a matched pair. This would allow for a quicker turnaround time, since only one of the sections may be awaiting a part, or in need of specific repairs.

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