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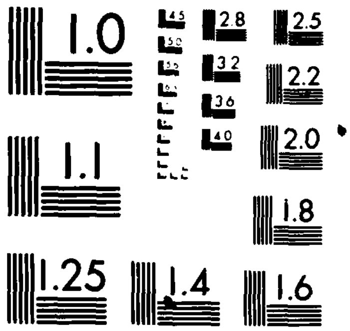

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THESIS

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OF THE NAVY'S AIR-LAUNCHED
MISSILE MAINTENANCE PIPELINE

by

Scot William Jones

June 1986

Thesis Advisor: John W. Creighton

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A Study for Reducing the Length of the Navy's Air-Launched Missile Maintenance Pipeline

by

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Lieutenant, United States Navy
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Submitted in partial fulfillment of the requirements for the degree of

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ABSTRACT

This thesis examines the Navy's air-launched missile maintenance pipeline to determine reasons for lengthy missile out of service time and find ways to reduce that time. It identifies areas of potential improvement and makes recommendations to take advantage of these opportunities to reduce the length of the pipeline and increase missile asset readiness.

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I. GENERAL INFORMATION

A. STATEMENT OF NEED

The Chief of Naval Operations (CNO) missile maintenance delay time standards are not being met at this time. Missiles which go into the pipeline and require repair at the depot level are out of service for 200-300 days as opposed to the 150-175 days allowed by the delay standards. The actual time spent on maintenance is estimated to be about five days at the intermediate maintenance site and 15-25 days at tne depot site. The rest of the time is consumed by various delays such as awaiting maintenance and awaiting transportation. If turnaround time can be reduced, asset readiness will be improved. [Ref. 1]

Asset readiness is the driving force behind efforts to reduce the length of the pipeline. The CNO has established Asset Readiness Objectives (AROs) which are the desired levels of Ready-for-Issue (RFI) missiles in the inventory.

$$\text{ASSET READINESS RATIO} = \frac{\text{Number of RFI Missiles}}{\text{Total Number of Missiles}}$$

There is a good deal of concern about the delay time in the maintenance pipeline because the present inventory is expected to triple by 1991. In addition, six new missile types are projected to be added to the inventory over the next five years. These changes present an opportunity to make changes in the missile maintenance pipeline to reduce the turnaround time.

The missile maintenance program is a major budgetary item. Missile costs range from around $50,000 per missile to over $1,000,000 per missile. Current maintenance costs for personnel are estimated at $25-30M per year, with the total man-hour workload projected to grow from approximately 450,000 man-hours in 1986 to over 1,300,000 man-hours for 1991. Over $130,000,000 in military construction has been requested for the next five years for storage and production facilities. [Ref. 2]

The basis for the missile maintenance pipeline has come from the maintenance programs for other types of ordnance such as torpedoes and mines. Maintenance support for a specific missile was designed without a coordinated approach to the other missile systems. This was not necessary when there were relatively few missile types, but with the increasing number of missiles and their increasing complexity, it is necessary to plan for growth in the system. There are not enough production and storage facilities to meet the future need. More will be required. The same is true for the production workers. This maintenance program has grown so rapidly that the reason for doing things in a certain way may no longer be valid. To minimize the cost of operation, it is time to closely examine what is being done and to try out ideas that show promise for reducing turnaround time, increasing asset readiness and reducing the maintenance burden.

Asset readiness has become increasingly important with the rising cost of missiles and the enactment of the Gramm-Rudman Bill. These factors may well limit the number of missiles that can be procured and force us to keep existing missiles in a high state of availability.

B. PURPOSE

The purpose of this report is to identify ways to reduce the maintenance turnaround time and increase asset readiness of air-launched missiles. An important objective is to make people aware that this program is a major concern and requires attention and planning now. The study will look at the maintenance system as a whole and attempt to identify bottlenecks and areas of deficiencies and make recommendations to resolve them.

C. BACKGROUND

The maintenance pipeline is the maintenance and logistics system by which non-RFI (Ready-for-Issue) missiles are made RFI. Naval Air Systems Command (NAVAIRSYSCOM AIR-418) is the Navy command responsible for the maintenance and logistic support of Air-Launched Missiles (ALMs). NAVAIRSYSCOM (AIR-418) does not own any missile maintenance or support facilities. These tasks are delegated to other commands, e.g., transportation and supply to Naval Supply Systems Command (NAVSUP); intermediate maintenance to Naval Sea Systems command (NAVSEA); depot maintenance to Naval Air Rework Facilities with NAVAIRSYSCOM (AIR-418) providing management for the program. [Ref. 10: p. 2-1-1]

The missile maintenance pipeline is designed to ensure that missiles receive periodic testing to screen out failures and return the failures to operational condition. Reasons for missiles to be inducted into the maintenance pipeline include:

* Failing built-in tests or an operational check while loaded aboard an aircraft.

* Reaching the missile's Maintenance Due Date (MDD).

* Being captive carried aboard an aircraft. This means that the missile is loaded onto an aircraft and flown.

* Being damaged in some other manner such as being dropped or exposed to salt water.

The air-launched missile inventory is currently composed of nine different missile types. Four of these will be phased out in the next five years. The inventory for the remaining systems is expected to triple and six new missile systems are to be added during this time. [Ref. 1] The current missiles are:

HARM	SPARROW	SHRIKE*
HARPOON	SIDEWINDER	WALLEYE* (some models)
PHOENIX	TOW*	STANDARD ARM*

*to be phased out

(Future):

AMRAAM	HELLFIRE	SKIPPER
PENGUIN	SIDEARM	MAVERICK

D. METHODOLOGY

The majority of the research for this study was done at the intermediate maintenance level at the three Weapons Stations that work on air-launched missiles. They are the central point of the missile maintenance system, having the greatest activity with respect to missile testing and repair. All air-launched missiles are sent to a weapon station and must satisfactorily complete testing before being issued to fleet units.

The missile systems examined are the *SPARROW*, *SIDEWINDER*, PHOENIX, and HARPOON. They were selected because they represent a large portion of the Navy's total air-launch missile inventory. They are well established programs that are expected to comprise a large portion of the inventory for a number of years to come.

This study follows the path of those missiles that fail because of their guidance and control (G&C) sections. Approximately 90% of all missile failures are caused by G&C sections [Refs. 2, 3, and 5]. The rocket motors, warheads, and superstructure of the missile are very reliable and result in very few failures. The primary Naval Weapons Stations associated with ALM maintenance are located at Yorktown VA, Concord CA, and Fallbrook CA.

The research for this report was primarily collected by interviewing weapon station personnel at Concord, Fallbrook, and Yorktown. There is little statistical data available to support the report because information has not been maintained on turnaround times except at the weapon stations on an individual basis. The data collected by the individual weapon stations does not use the same measurements.

The central conflict for the ALM maintenance pipeline is to determine which has greater priority, asset readiness or efficiency and economy of the maintenance pipeline. Both sides have valid arguments which deserve closer inspection.

E. SCOPE

The remainder of the report is divided into five sections. Each of these sections is briefly described to orient the reader and to assist in locating pertinent information.

Section II presents a more detailed look at the ALM maintenance pipeline. The role of the major commands involved is defined. System operation is described. This section provides background to the reader which may be necessary for understanding subsequent chapters.

Section III presents the major findings and recommendations of the report. Major findings and recommendations have been included as early as possible to allow evaluation of the report with a minimum of effort.

Section IV provides a breakdown by functional area where opportunities are for reducing delays and overall turnaround time.

Section V presents some ideas to the reader with the intent of promoting some free thinking of what "could be done."

Section VI summarizes the study and includes recommendations for further research.

II. DESCRIPTION OF THE MISSILE MAINTENANCE PIPELINE

A. COMMAND RESPONSIBILITY

NAVAIR (AIR-418) is the Navy command responsible for the logistics support of ALMs. Its function is the management (planning, programming, directing, and control) of field activities to accomplish specific tasks to fulfill this mission. Included in the mission is the responsibility for the maintenance of the ALMs. NAVAIR (AIR-418) does not own any maintenance facilities or support activities and delegates other commands to provide the support required (e.g., transportation and supply support from the Naval Supply Systems command (NAVSUP) and maintenance support from the Naval Sea Systems Command (NAVSEA).

The other major activity involved in the maintenance pipeline is the Pacific Missile Test Center (PMTC), Point Mugu, California. PMTC is designated as the Maintenance Engineering Activity for ALMs except WALLEYE. It provides support to NAVAIR Headquarters for basic design and maintenance engineering, and production support functions. It also provides type commanders with engineering and technical services for advice, instruction, and training in the installation, operation, maintenance and modification of airborne weapons and associated Weapons Support Equipment (WSE). The major function at the weapon station level is performing the ALM workload coordinating function and conducting ALM and WSE technical proficiency evaluations of Navy intermediate and depot level industrial facilities. [Ref. 10: p. 1-1-5]

The maintenance support is organized into three levels for air-launched missiles: namely organizational, intermediate, and depot level.

Organizational maintenance is the lowest level of repair and usually means a fleet operational squadron either onboard an aircraft carrier or at a Naval Air Station. Known as "O" level maintenance, it consists primarily of assembly and disassembly of the weapon. It involves no internal maintenance of the missile and only very limited surface maintenance. Limited tests, such as continuity and seeker head checks, are performed aboard aircraft at the organizational level.

Intermediate maintenance (or "I" level) is performed at Naval Weapon Stations (NWS), also known as IMAs (Intermediate Maintenance Activities). This maintenance level consists of testing and component replacement. The weapon station is the central point for the pipeline. All new production, reworked, and fleet return weapons must successfully complete testing at the weapon station before being issued for use. Missiles are tested as All-Up-Rounds (AURs) at the weapon station. This means that all missile sections are assembled to form a complete missile before any testing is done. [Ref. 1]

Depot level maintenance is performed at NARFs (Naval Air Rework Facilities) and contractors' plants. These depot level maintenance facilities are also known as Designated Overhaul Points (DOPs). This is the most extensive level of repair. It consists of diagnostic testing and detailed component and subcomponent repair of assemblies and sections that failed testing at the weapon station. These maintenance facilities are widely dispersed across the United States.

B. SYSTEM OPERATIONS

As an aircraft carrier is preparing to deploy, a weapons load-out request is sent from the carrier to the weapons stations. The stations prepare the load-out of missiles by selecting missiles from their RFI inventory with 12 months remaining before their maintenance due dates (MDDs). If enough missiles are not on hand, the stations will rearrange their workloads to provide the additional missiles.

When the missiles are loaded aboard the carrier, one of three things will happen. The missile will be:

1. placed into deep stowage in its container;
2. taken out of its container and built up in the Ready Service locker;
3. removed from container, built up, loaded onto an aircraft and captive flown. (Captive flown means that the weapon is loaded aboard the aircraft, which is launched and recovered, without firing the missile.)

The prime contributor to missile failures onboard the carrier is being captive flown. All missiles that are captive flown must be sent to a weapon station for testing.

There are different limits for the number of flight hours or launches and recoveries determining how long each missile type may be flown before being down-loaded and considered Material Condition Code E, Unserviceable (repairable). [Refs. 2, 3, and 5]

1. Missile Pre-sentencing Inspection

A Missile Pre-sentencing Inspection (MPI) team is sent to the ship 2-4 weeks before the end of the deployment. The mission of these teams is to inventory all missiles onboard and determine which ones need to be sent back to the weapons station for maintenance at the end of the deployment and which ones may be cross-decked to another ship or station. These teams are composed of representatives of the Pacific Missile Test Center, Point Mugu, CA (PMTC) and the respective weapons stations. [Ref. 7]

These teams are sent to the carriers with a master inventory list for the missiles that should be board that particular carrier. They physically sight either the missile or its documentation to make sure that the master inventory list is accurate and decide any questionable cases. Quite often, there are numerous discrepancies on the master list. Missiles that require maintenance or testing are consolidated into shipping containers for transport to the weapon stations. Color-coded tags are attached to the containers for easy recognition and sorting. [Refs. 3 and 5]

2. Transport from Ship to Weapon Station

Missiles that do not require maintenance or testing are cross-decked to another carrier. Some missiles that require maintenance are sent back to the weapon stations on a space available basis on either ships or aircraft. This amounts to less than 2% of all missiles that require maintenance from the carrier.

3. Arrival at the Weapon Station

The missiles requiring maintenance are usually cross-decked to an ammunition ship for delivery to a weapon station or a port where the missiles can be shipped to a station. The missiles are off-loaded and again inventoried, this time for receipt. After the weapon is inventoried on the pier or loading dock by station quality assurance people, the weapon is placed into temporary or permanent storage. Permanent storage is a magazine. Temporary storage might be a shed or a rail car until the missile can be put into a magazine.

4. Documentation

The form used to record the data which tells the station that a particular missile is onboard is the DD-1348, which is a shipping document. This form is sent to the AD&C (Ammunition Distribution and Control), where the paperwork is turned into a data entry for the NOMIS (Naval Ordnance Management Information System) report.

The NOMIS report has two forms. There is a monthly form that lists every missile that is physically aboard the station and what its status is. The second form is a daily

NOMIS report which only lists the missiles that have had a change in status. No scheduling of work may be done until the missile's paperwork has been processed and the production people notified of its location and status. This commonly takes 3-4 weeks. The reasons given for this delay include heavy workload, inexperienced personnel due to high turnover, the large quantity of missiles that arrive at one time, and the large amount of data entry that is required for each missile. [Ref. 5]

The receiving inventory reports are known for being inaccurate as well as late. One thing that could be done to reduce this delay is to have the station use a copy of the master list that is sent with the pre-sentencing team to enter applicable data before the missiles arrive at the station. When the team completes their work, a message could be sent to modify the master list. This would reduce the off-load paperwork to an exception-only basis and reduce the time from weapon arrival until notification of production personnel that the missiles are on station.

5. <u>Workload Scheduling</u>

Once a missile is known to be on the station, the weapon is scheduled for maintenance. This is done by the station planning personnel. The scheduling of missile testing and repair has several variables that determine the order of induction. Some of the variables include the asset readiness ratio for a particular missile type and the priority need for a missile type to complete carrier load-out.

Two major planning conferences are held each year between the NAVAIR (AIR-418) people, Pacific Missile Test Center (PMTC) and weapon station representatives. The purpose of the first conference is to determine how much work will be assigned to each station and when the work is expected to arrive. The work assignment is based on competition and a "fair share" principle. The fair share principle essentially divides the missiles according to the projected needs of three commands, CINCLANTFLT, CINCNAV-EUROPE, and CINCPACFLT. Each missile type is only worked at one site per coast. The second conference is the mid-year review, which is used to make adjustments as necessary to the previous schedule. [Ref. 6]

6. Into Maintenance

Production at the weapon stations is seldom a continuous process for any missile type. This is due to the lack of test equipment, test cells, and production workers to keep all missile repair lines open continuously. The weapon stations are not allowed a backlog to ensure a constant flow of work. They are driven by the delay standard for inducting missiles into maintenance and the need to maintain the asset readiness levels.

At Concord, only HARPOONs and SPARROWs are worked and each have their own production building so work is nearly continuous. Weapons are scheduled by priority for a particular model, such as the AIM-7F or -7M, for SPARROW. Fallbrook repairs all the other types of ALMs for the West Coast. Yorktown maintains every ALM type in the inventory for the East Coast.

Another factor that determines when a missile will be worked is the funding for the maintenance. If a station has not been funded to perform maintenance on SIDEWINDERs for a given quarter or if they have already spent their allotted funds for the quarter, no more SIDEWINDERs will be worked unless there is a priority demand, an additional funding, or the Commanding Officer of the station gives station money to the project. The last is usually done only when a program has run out of funds prior to completing their assigned quota. [Ref. 4]

When the missile is ready to be inducted into maintenance, it is brought to the production facility in its container. Missiles are usually broken out in lots that represent a week's production output. This varies at the different stations with the availability of assets to move missiles around the stations. The missiles are taken out of their containers as assembled all-up-rounds (AURs), and tested as an AUR.

The purpose of the test is to determine if the weapon meets operational standards or whether it needs repair. If a missile passes this test, it is considered an up round and given a Condition Code A, Serviceable (Issue without Qualification). Corrosion work or cosmetic work may be done to the missile as long as no connections are required to be undone. The missile is put in its container, has its paperwork updated and is given a new MDD before being put back in the magazine awaiting issue. Once the missile has been designated Code A, it is ready-for-issue and no longer considered in the maintenance pipeline. These steps are recorded on the Maintenance Data System (MDS) form. This form is a step-by-step record of the assembly, disassembly, and maintenance of the missile. It also tells which components are used to make up the round. Each component section of a missile has its own serial number. A complete round is usually identified by the serial number of the guidance and control sections. A report is required every time that the missile's condition code changes.

7. <u>Failed Sections</u>

If a missile fails a test, it is usually retested on a different test set. If the missile fails a second test, the repair process begins. The first step is to locate the section that is causing the failure. When the section or component causing the failure is identified, it is removed from the missile and replaced with a spare from the rotable pool or a component removed (cannibalized) from another missile if one is available. The missile is then retested. If it passes, it is considered a Condition Code A missile and put in its container. If the missile fails testing again, the process of locating the failure continues until the weapon is back in serviceabale condition. If no spares are available, the missile is disassembled, put into component containers, and returned to storage in Condition Code G, Unserviceable (Incomplete). It must be inducted into maintenance again when a spare becomes available.

8. Weapons Quality Engineering Centers

Weapons Quality Engineering Centers (WQECs) are used to verify suspicious failures. They have more accurate and elaborate test equipment than the production facilities do. They will test a missile and determine whether the failure of the weapon is accurate or if it is a false reject. A false reject is a failure caused by an inaccurate test set. WQEC also performs quality monitoring functions to provide an assessment of weapon and component stockpile readiness, service life measurements, measurements of degradation and analysis of factors adversely affecting weapon quality, reliability and serviceability. [Ref. 10: p. 1-1-6]

9. Awaiting Shipment to Depot Maintenance

The failed components that are removed from the weapon are put into component containers and placed in storage waiting for shipment to a DOP. The DOPs are NARFs Norfolk and Alameda and prime contractors such as McDonnell-Douglas for HARPOON and Raytheon and Ford-Philco for SIDEWINDER. The contractors are used as the DOP when a new missile type or model is introduced until the NARFs are ready to assume the depot level maintenance. [Ref. 1]

10. Transportation to Depot Maintenance

Transportation to the DOP is normally provided through the supply system. A missile leaving the station at Concord to be repaired at NARF Alameda would be sent to Naval Supply Center (NSC) Oakland. It would remain there until NARF Alameda needed more sections to work. NARF Alameda would then requisition the needed sections through the supply system. Once the section is repaired at the NARF it is sent back through the supply system to NSC Oakland as a Code A section. Code A guidance and control sections are considered equivalent rounds and no longer count against the asset readiness objectives.

One notable exception to this transportation system is the HARPOON missile. The HARPOON maintenance program was taking too long to get a missile section through the DOP at the McDonnell-Douglas facility in Missouri. Much of the time was being spent waiting for transportation to the DOP. To speed up the process, a dedicated transportation system was established to do nothing but move HARPOON missile sections between the weapon stations and the DOP. This system is composed of one tractor and four trailers. The truck leaves the DOP with a trailer of Code A missiles and drives to NWS Concord where it drops off the good missiles and picks up a trailer already loaded with sections needing repair. This trailer is driven to the DOP where it is dropped and a load of good sections picked up for NWS Yorktown. The tractor switches trailers again and completes the figure eight.

The tractor arrives at each station once in a two-week period. Using the dedicated transport, it takes about 36 hours to drive from Concord to the DOP, with the time being less between Yorktown and the DOP. Under this system, the average turnaround time for HARPOONs requiring DOP maintenance from Yorktown has dropped from 244 days to 166 days based on in-process time monthly averages. [Refs. 1, 2, and 5]

11. <u>Maintenance at Depot Level</u>

When the failed sections arrive at the DOP, they undergo detailed diagnostic testing and repair. The repair process at the DOP is continuous for the different missile types. The DOPs are allowed to work with a backlog to ensure a steady work flow. When maintenance is complete, the sections are given a Condition Code A and put back into the supply system for return to the weapon stations. Once the sections are back at the station they are used as spares to repair other missiles. The spares are used to build AURs which are then tested, put into containers, and returned to storage Code A. Once the missile is given a Condition Code A, it is considered out of the maintenance pipeline.

III. MAJOR FINDINGS AND RECOMMENDATIONS

The following subsections describe the major findings of this study and provide recommendations to help eliminate deficiencies. There are several areas where changes could be made that would reduce the amount of time that a missile is in the pipeline. The following areas are given special mention because I believe that they could provide large improvements in pipeline effectiveness and because the recommendations would be relatively inexpensive to initiate. They would be easy to implement on a trial basis for a single program or station.

A. INACCURACY OF INVENTORY REPORTS

Throughout the maintenance system, the largest complaint is the inaccuracy of the inventory reports. The majority of the inaccuracy is caused by the delay in getting information entered into the Conventional Ammunition Integrated Management System (CAIMS) reports. Inputs for CAIMS come from:

- Ammunition Transaction Reports (ATRs) from aircraft carriers and ammunition ships. These reports are sent out by message.

- Naval Ordnance Management Information System (NOMIS) reports from weapons stations.

- Transaction Item Reports (TIRs) from Navy and Marine Corps Air Stations, Naval Air Rework Facilities (NARFs) and Pacific Missile Test Center (PMTC).

All of these reports are first handwritten and then entered into a computerized format. There is commonly a 2-4 week lag time between the actual transaction and the time that it appears in the CAIMS report. The CAIMS report is used to determine what the asset readiness for the system is and the priority for missiles to enter maintenance.

The CAIMS system is being upgraded. The improvements include a system of 41 reporting points in the repair process. The reporting points are specific maintenance actions that will give a clearer picture of where time is being spent in the pipeline. To assist the system, the OMS system is being added. This system will use bar coding on the various missile sections and a bar code reader for data entry. The first installations are to begin in the summer of 1986 with the entire system becoming operational in 1989. [Ref. 1]

In the interim, there are some actions that could be taken to reduce the amount of data entry required. These actions should be easy to implement and require little funding.

1) A comprehensive review of required reports needs to be made to eliminate, simplify, and combine as many of the reports as possible to avoid redundancies and purge the system of requirements that are no longer valid. This method would be especially applicable to older programs such as SPARROW and SIDEWINDER and the programs that are to be phased out. These programs have large historical data bases and trends are well established. Records kept would be limited to essential information only.

2) Reduce the backlogs that occur when a carrier off-load arrives at a weapon station by entering as much

information as possible beforehand. The off-loads flood the Ammunition Distribution and Control offices at the stations with paperwork to be entered into the computers. Much of the information is available through the master inventory lists that the Missile Pre-sentencing Inspection teams are given by Fleet Analysis Center (FLTAC) before their inspections.

3) Have the inspection teams send messages from the ship for any changes that are expected on the master list.

4) Hire additional data entry personnel.

B. TEST EQUIPMENT AND CELLS

There are bottlenecks at Fallbrook and Yorktown caused by shortages of test equipment or test cells. All cells are scheduled for 100% use during normal working hours. At Concord the two SPARROW test sets and cells are fully scheduled but the two HARPOON cells are used to about 50% of normal capacity and there is a fifth cell in a separate building that is not in use. [Refs. 7, 8, and 9]

This is a limiting factor for the entire pipeline. The system cannot push missiles through any faster, regardless of what is done with the rest of the pipeline. There are four alternatives:

1) Increase the amount of test time that is available by obtaining more test sets.

2) Operate the test sets longer hours.

3) Shorten the testing time. Tests for the SPARROW missile take approximately one hour to run. If the time could be reduced to 25 minutes, then the number of missiles that could be put through the cell in one day would increase.

4) Reduce the amount of testing that must be done on a missile. This could be done by increasing the time between maintenance for missiles. It could also be

accomplished by testing sample batches of missiles out of depot maintenance and new construction instead of testing every missile.

A word of caution should be included. Because of the critical mission of the missiles, it is important that any changes in the testing procedures or any other procedure do not affect the performance of the end item. If the increases in the output of the maintenance pipeline are offset by decreased reliability in the missile, nothing has been gained and aircrews and their aircraft have been jeopardized. Any changes to the maintenance system must be well engineered to ensure continued quality and reliability of performance. The main purpose of the maintenance program is to provide missiles that will perform their mission. Any other considerations are strictly secondary in nature.

C. LACK OF PRIDE AMONG PRODUCTION PERSONNEL

There is a lack of pride among many of the production workers. They are not held responsible for their work. The responsibility is held by the Quality Assurance inspectors. Because the workers are not held accountable, they have no incentive to improve their performance. The industrial standards that are allowed are generous yet they frequently are not met. The exception to this lack of pride and concern seemed to be at Fallbrook. Fallbrook has an extensive training program that stimulates interest in what they are doing.

I recommend that the production workers be organized into small teams and that the responsibility for the work performed be given to the team leader. The Quality Assurance inspector would only inspect highly unusual tasks or the most critical tasks. This would do four things:

1) It would give the workers much more responsibility for their work.

2) It would give them more pride of ownership for the work that they do.

3) It would increase the accountability for the work that was being performed.

4) It would be easier to identify workers who were inadequately trained or unmotivated, and would increase the number of workers available for production by decreasing the number devoted to Q.A.

D. INEFFICIENT PRODUCTION METHODS

I feel that the delay time standard for inducting missiles into maintenance within 15 days of arriving at the weapon station may be detrimental to the goal of higher asset readiness and lower operating costs for the stations. There is little opportunity to realize any benefit from the learning curve. Set-up times are increased when production is shifted from one type of missile to another on a weekly basis.

Repair at the intermediate level is essentially a straightforward, manual labor production process. Most of the operations are common to every missile. As a production run continues, there should be a reduction in the amount of time that it takes to accomplish these standard operations, the learning curve effect. Because the production lines are shut down and switched every 1-2 weeks, much, if not all, of this gain is nullified. The purpose of the delay time standard is to move missiles through the maintenance pipeline quickly and keep asset readiness high.

If this delay standard were not enforced and missile types were worked continuously for several weeks, I believe that the overall asset readiness would increase. More missiles could be worked because the average time to perform the maintenance would be decreased. With fewer set-up changes, there would be more production time available. Although a particular missile type might dip below its asset readiness objective, the other missiles in production would be far enough above their objectives that overall readiness would be higher.

This program would probably save money by reduced man-hours spent on equipment set-up. Other benefits that might be realized include: the economy of moving all the missiles out of one magazine, and having full truckloads of missiles to ship instead of partial shipments.

E. DEDICATED TRANSPORTATION

One area that has shown great promise for reducing delay time is dedicated transportation. Dedicated transportation means that a long-term agreement is made with a trucking company to provide regularly scheduled transport service exclusively to carry a particular type of missile between points. For example, having a truck pick up a load of SIDEWINDER missiles from a particular weapon station every Friday and deliver them to a particular DOP on Monday morning.

Dedicated transportation for the HARPOON program reduced turnaround time through the DOP by an average of 50 days over a six-month period through January of 1986. This might also be done with other missile programs, particularly the more expensive missiles. This program is expensive but by reducing the pipeline 50 days it reduced the number of missiles in the pipeline by around 20%.

F. RECOMMENDATION

1. Eliminate Delay Time Standards

One recommendation would be that the term "delay time standard" be replaced by the term "productivity standard." At first glance this would appear to have little or no effect on the amount of time that a missile spends in the maintenance pipeline. However, if a "delay standard" exists for a portion of the pipeline, there will be a delay. It is expected to occur, so it will occur. If the term "productivity standard" is used, it implies a goal to be met. This becomes a challenge and encourages people to find ways to eliminate delays.

IV. POTENTIAL FOR IMPROVEMENT

A. GENERAL

The pipeline has room for improvement in several areas including personnel, transportation, facilities, data collection, and production. There are opportunities to reduce the turnaround time and to implement ideas that will accommodate the growth of the missile maintenance programs. Change in one area may well mean that another area will have to change. Suggestions in this chapter are *not* a comprehensive list, just the more notable ones. Many systems sufficient for the past have been outgrown. Restructuring is needed to improve the performance of the pipeline.

B. PERSONNEL

Maintenance performed in the pipeline is labor intensive. The only operations that are automated are the tests performed on the missiles and their components. At Yorktown and Fallbrook all workers are civilians. Concord has some Navy personnel assigned to limited areas of production such as wing and fin repair, rocket motor repair, container repair, and some test monitoring. The issues in personnel are:

1) A lack of pride and motivation among many of the production workers.

2) High rate of turnover for test equipment operation at Yorktown.

1. Lack of Pride and Motivation

Many of the production workers do not seem to take pride in their work. Some of this may be attributable to the tedious nature of some of the tasks and the lax time standards that are given to complete work. The main factor appears to be that the workers feel no responsibility for or identity with the work they do. Their work is certified by a Quality Assurance representativew. It is the Q.A. rep who takes the responsibility for the work and puts his stamp on the missile. The production workers learn the tolerances of the different Q.A. inspectors and gauge their work to pass the inspection. The workers feel no pride of ownership in the work performed. [Refs. 2 and 5]

Several people interviewed were familiar with all the weapon stations and felt that the workers at Fallbrook showed the most interest and concern for their work. Fallbrook has approximately half the number of workers as the other stations. Every production worker is put through an extensive training program. At the completion of that training program the workers are qualified to perform every maintenance task performed on each type of air-launched missile worked at the station and are rotated on a regular basis. It takes 4-5 years to become fully qualified on all systems.

Recommendations:

1) Give the responsibility for the work to the workers who perform it. Organize the workers into small teams that

would work the missiles through the production process from start to finish. The group supervisor would be responsible for the work performed on the missile and would sign off the work performed. Q.A. inspectors would be used only for extraordinary cases.

2) Adopt the Fallbrook training and rotation program at other stations. This would provide the workers with a broader range of experience. Techniques used on one program might carry over to another.

2. Low Pay for Test Equipment Repair Technicians

One issue at Yorktown was that test equipment repair technicians were hired by private industry as soon as they became qualified. They were being hired away because their pay is low with regard to the industry standards in the area.

Recommendation:

Raise the wage grade for these technicians at Yorktown.

C. FACILITIES

The facilities in the system are loaded to capacity. They will be inadequate with the increase in size of the inventory and the introduction of new missile systems. Fallbrook and Yorktown both seemed to have critical shortages of production and storage space. In interviews with PMTC representatives at Yorktown, they felt that the station would have to turn work away by 1989 due to a lack of space. The station is currently using rail cars for storage of missiles. [Ref. 2]

Some of the facilities deficiencies for the stations include:

1) A shortage of test equipment/test cells.

2) Shortages of missile magazine space.

3) Shortage of production facility space.

4) Lack of a receiving facility at NARFs so that missile sections could be shipped direct between the weapon stations and the NARF.

1. <u>Test Equipment/Test Cells</u>

A critical deficiency at the weapon station level is the limited availability of test equipment and test cells. The test cells at the stations, with the exception of Concord, are scheduled for 100% use during working hours. Concord has five test cells, one of which is idle. The two cells used for SPARROW are in use 100% of the time. Estimated use of the two HARPOON cells is 50% of the time. If a WALLEYE is being tested, no missiles may be tested in adjacent cells because of explosive limits. This further limits the amount of test cell time that is available. Production is bottlenecked at this point and the turnaround time for the entire pipeline cannot be reduced until more testing capability is realized. [Refs. 2, 4, 5 and 8]

Recommendations:

1) Buy more test equipment and build more test cells. This will have to be done eventually.

2) Reduce the length of the tests that are run to increase the rate of testing. The test for SPARROW missiles takes about one hour to run. If this test could be shortened to 25 minutes, the number of missiles that could be tested on one test set would increase.

3) Improve the test equipment so that more accurate repair is possible and repeated retest is reduced.

4) Reduce the number of missiles which must be tested. This could be accomplished by increasing the length of the SIST or by not testing every new construction and reworked missile. All missile sections coming out of

new production or rework are tested as AURs before being issued for use. The acceptance rate for some missile systems is greater than 95% during this testing [Ref. 5]. If all missiles were retested the next day, they would probably have the same failure rate. I propose that for long-term, stable programs this testing be done in sample batches and not done for every missile unless there is a major change to the missile.

5) Operate the test equipment for longer hours. At present, they are normally scheduled for operating one shift per day.

6) Obtain a DSM-156 test set for SPARROW and put it in one of the HARPOON cells at Concord. Bring the WALLEYE maintenance to Concord and set it up in the building with the single test cell.

2. Magazine Space

There is a physical shortage of magazine space. Yorktown is presently storing missiles in rail cars. When a magazine is at 80% of its capacity, it is considered full because it is difficult to efficiently move weapons in and out.

The magazine space that does exist was built to accommodate conventional ordnance, not missile containers. On the older magazines the doors are so narrow that two forklifts are required to move the missiles around. One forklift is used exclusively outside the magazine to unload missiles off the truck and bring them to the door where they are turned lengthwise to fit through the door. The exterior forklift then repositions and lifts the containers lengthwise and moves them inside the building where the other lift picks them up in the normal fashion and stacks them for storage.

This maneuvering probably takes two to three times as long as it would with doors that were the proper width. [Ref. 4]

These two factors create difficulty in rotating stock and increase the costs of moving missiles into and out of storage. A study was made a few years back and it was determined that it would be less expensive to build new magazines with wide doors than to widen the doors of the existing magazines. [Ref. 5]

Recommendations:

1) Build new missile magazines. For FY 1988-1992, the Program Objectives Memorandum requests for weapon station Military Construction total $130,000,000, of which $105,000,000 is for magazine construction. None of this money has been approved in the Five-Year Defense Plan yet.

2) Replace conventional magazine doors with missile doors. This option was looked at before. At the time, it was felt that it would be more expensive to do this than to build new magazines. This may have changed since the study was done. The magazines will be needed. Storing missiles on rail cars is unacceptable as a safety risk and as a potential target for terrorists.

3. Production Space

The difficulty in moving weapons in and out of magazines and a shortage of trucks to move missiles onboard the stations lead to the need for increased production space. If moving missiles onboard a station were easy, missiles to be inducted into maintenance could be broken out on a daily basis. At Yorktown, a week's worth of missiles are brought out at one time, making it necessary to have room on the production floor for the entire week's workload.

Production facilities are limited by the explosive weight of the weapons on the floor. Explosive weight is measured as the warhead weight plus a percentage of the solid rocket motor. Certain missiles, such as WALLEYEs and HARPOONs, may not be worked on at the same time because the explosive weight of the production run exceeds the explosive limits of the facility.

Recommendation:

1) Improve the magazines and the on-station handling ability and the need for increased production space would be reduced until the new missile types comes into the inventory. Each missile type should have its own test cell so that test equipment does not need to be moved. WALLEYEs should be worked in separate buildings so that other test cells are not rendered unusable for significant periods of time.

4. NARF Receiving Facility

Another facility shortage is the lack of a receiving facility at the NARFs. All weapon components that are sent to the NARFs must be routed through the supply system. Missile components from NWS Concord must be sent to NSC Oakland, where they are stored until the NARF is ready for more work and they requisition the components. This occurs both coming to and returning from the NARFs on both coasts. This causes delays because it doubles the number of times that the sections must be handled. I believe a month could be removed from the turnaround time if the NWS and the NARF could ship missiles directly to each other if the rest of the system could accommodate the change.

Recommendation:

Build a receiving facility at the NARFs so that material may be shipped directly between the weapon station and the NARFs.

D. TRANSPORTATION

The transportation area is of particular interest because of the large potential for reducing turnaround times. Transportation is required to move weapons:

- from where they are deployed overseas back to the U.S.
- from the ships that return them to the U.S. to the weapon stations where they are repaired.
- aboard the weapon stations.
- between the weapon stations and the DOPs and back to the stations.

Transportation opportunity areas include:

1) Returning missiles that fail while on deployment to the U.S.

2) Inconvenience to trucking companies.

3) Authority to ship missiles and components is not given to the individual stations, but is controlled by an inventory manager for each missile type in Washington, D.C.

1. Return of Deployed Missiles

Off-loads from aircraft carriers occur 2-3 times per year for each coast. The failure rate for missiles is fairly constant throughout the duration of the cruise. The time that these failed weapons are carried around on the carriers is not being considered in the pipeline measurements but should be. The Navy has tried to return these weapons on a space available basis but it is estimated that less than 2% of the failures are returned in this manner. [Ref. 6]

Recommendation:

Use MSC ships or rotate ammunition ships to bring failed missiles back halfway through the deployment.

2. Inconvenience to Trucking Companies

Many commercial trucking companies are reluctant to do business with the government. The reason for this is the extra requirements and paperwork that the government requires. The paperwork is more detailed and complicated than that used by commercial shippers. Many of the forms provide redundant information. These forms require more office work and lead to longer delays. Some of the other requirements include:

1. Two drivers for each vehicle.
2. Tarps to cover the missiles.
3. Carrying firearms for protection against terrorists.

Another reason that trucking firms are reluctant to haul missiles is that their trucks and trailers can be tied up for weeks waiting for full loads. The Navy places a standard DOD transportation priority on the movement of unserviceable Code F missiles. As a result, the missiles are not shipped with less than a full truckload.

This can lead to delays in two ways. One is, the truck can be filled with other items that do not have the same destination, so the missiles can be delayed for weeks while the truck delivers the rest of its load. The second way is for the truck to wait to be filled with missiles. The current method of processing missiles is not a continuous production line. It may be several weeks before that particular missile type is worked again. In the interim, the trailer may sit waiting to fill out the load. This may not be cost effective considering the high cost of these missiles.

Recommendation:

Use dedicated transportation on a fixed schedule as the HARPOON program is doing. This is an area that has demonstrated potential for reducing delay time.

3. Authority to Ship

The stations do not have the authority to ship missiles requiring WQEC verification on their own. The missile type inventory manager in Washington D.C. holds that authority. Missiles waiting for shipment to WQEC for verification must remain at the station until the inventory manager approves the shipment or until the missiles have waited 30 days for that approval. The station normally ships the missiles after 30 days without receiving the approval. Approximately 5-10% of all new and reworked missiles require this verification. [Ref. 5]

Recommendation:

Grant stations the authority to ship missiles to WQEC for verification.

E. PRODUCTION

The production processes at the weapon stations show some possible improvements. The areas that appear to provide the best opportunities for performance improvement are:

1) Length of production.

2) Production layouts.

1. Length of Production Run

The length of production runs is at the heart of a conflict between NAVAIR and NAVSEA. NAVAIR wants to maintain high asset readiness at all times and wants missiles to be moved into production within 15 days of arriving on station. This necessitates breaking production runs after one or two weeks. NAVSEA wants to operate the maintenance pipeline in as economical a manner as possible. This means long production runs to avoid disruptions and set-up delays in the production process.

Recommendation:

Eliminate the delay standard for inducting a missile into maintenance. Increase the length of the production runs. The potential increases in production come from the learning curve effect and the reduction in set-up times for the test equipment.

2. Production Layout

The production layouts vary greatly between the stations. At some stations, the work is confined to a small area so that everyone is aware of its status. Help is readily available if a problem develops. At other stations, the work is spread throughout the building.

Recommendation:

Try to keep the production area for a missile type in one, close area. This will keep everyone aware of the work's status, eliminate excessive movement of the missile and its components throughout the production facility, and allow help to be readily available if needed.

F. DATA MANAGEMENT

Performance of the pipeline might also be improved through some changes in reporting and data management. The place where improvement is needed is in the accuracy of the inventory status reports.

The area that provides the most opportunity to improve asset readiness is in increasing the accuracy of the inventory reports, such as CAIMS. Most of the inaccuracy is due to the time delay in getting data entered. In many cases it takes 3-4 weeks from the time the transaction occurs until the data is entered into these reports. [Refs. 2, 3 and 5]

All data must first be hand recorded onto a form, then the form is taken to A,D&C, where it is entered into a computer data base. Several people interviewed believe this to be the main obstacle to improving the performance of the pipeline. Benefits of correcting the reports would include better planning and better use of available assets.

Recommendations:

1) Eliminate any reporting requirement that is no longer valid. Simplify and combine what is left to avoid redundancy. Reduce the workload by reducing the amount of reporting required.

2) Pre-enter as much data as possible to reduce the workload at end of deployment off-loads.

V. IDEAS FOR CONSIDERATION

This section is included to give the reader something to contemplate, and to provoke further thought on the subject of missile readiness and maintenance. The author realizes that there are many obstacles to the possibilities mentioned, but that with coordinated effort and wise resource commitment, some might be of use. A key concept for the reader to keep in mind is "What are the possibilities?" rather than "What are the problems?"

A. CREATE A NAVAL WEAPONS SYSTEM COMMAND

The missiles in the Navy's inventory are very complicated and expensive pieces of equipment. They perform a vital role in national defense. The support system to keep them in service is extensive and complex. They are deserving of their own major command.

The advantage of this would be that the entire maintenance pipeline would be under one command. There would be no conflict between commands over priorities and how things should be done. Changes in the system would be easier to implement because everyone in the system would be working for the same boss.

B. DEDICATED TRANSPORTATION

Another possibility would be for the Navy to have its own weapon transportation services rather than hire commercial truckers. The transportation of military weapons has been receiving attention in the press lately for inadequate security from theft and terrorist actions. With all the attention, it won't be long till even more strident requirements are placed on commercial carriers of the Navy's missiles. In the long run, it might be less expensive for the Navy to have its own tractors, trailers and drivers than to hire these services.

With the media attention, this would probably be the most opportune time to make a case for the Navy's buying its own trucking services. It would eliminate having to contract out each job, obtaining security clearances for the drivers, and other problems that need to be overcome when purchasing the transportation from commercial sources. The trucks would have regular schedules and could operate with less than full loads. Costs should remain fairly constant regardless of whether the trailer was full or not. The trucks would only be used by the NAVAL WEAPONS SYSTEM COMMAND. They would proceed directly to and from the destination instead of making several intermediate stops to drop off other partial shipments.

C. ELIMINATE TRANSPORTATION

The current missile maintenance system has never been tested under full-scale wartime conditions. Missiles did not exist during World War II, and the Korean and Vietnam conflicts were not real tests of war conditions for the U.S.

at home. During war, transportation is a major concern. There are many competing demands for the transportation that is available and the transport systems are susceptible to attack. The present missile maintenance system is built around peacetime resources and the author doubts that it could continue to function during wartime.

The best way to reduce transportation problems is to eliminate as many of the transportation requirements as possible. This could be done by building all of the maintenance facilities at the ports where the ammunition ships return to CONUS. This would include the intermediate and depot level maintenance as well as WQEC. The only transportation requirements would be on station.

This would minimize the amount of facilities and storage needed by eliminating redundant excess capacity. The number of administrative personnel, weapons handling personnel, etc., required would be reduced. Test equipment and skilled personnel would all be in one location to assist if a problem or backlog developed. Transportation time would be reduced to the time required to process the paperwork and move the missiles across the street.

D. DREDGE THE RIVER

While the author was visiting Fallbrook, he was told:

> Several years ago, a land developer in Los Angeles offered to dredge the river onto the weapon station at Fallbrook so that ships could come up the river and deliver the missiles directly to Fallbrook. His asking price for doing this was the property at Seal Beach Naval Weapon Station. [Ref. 3]

If the story is true and the offer still stands, perhaps the Navy should take him up on it. Missiles and weapons that are maintained at Fallbrook normally first arrive at NWS Concord and then are shipped to Fallbrook. This can result in delays of as much as two months from the time the missiles arrive at Concord until they arrive at Fallbrook.

Another idea proposed is to have helicopters transport the weapons from the ships while they are at anchor off the coast. The helicopters used for this type of operation are home-ported at NAS North Island. The two difficulties to overcome are overflying Interstate 5 while externally carrying missiles and transporting the missiles from the landing pads and runways at Camp Pendleton to the storage facilities.

E. CHANGE DEPLOYMENT SCHEDULES

One way to avoid having missiles that fail at the beginning of the deployment from sitting on the ship till the end of deployment is to have the ammunition ship rotate at the middle of the carrier's deployment.

This would do three things:

* It would allow missiles to come back to the maintenance system sooner so they could be repaired sooner and keep asset readiness higher.

* It would more evenly distribute the workload at the weapon station.

* It would allow missiles with little time remaining till their MDDs to be used more effectively. Instead of needing 6-12 months remaining till their MDD to be sent on deployment, a missile could be sent out that had only

> 3-4 months. This would allow greater flexibility and usage of the available missiles and better use of the missiles since they would not need to be tested as often.

Military Sealift Command ships could also be used to perform this function.

F. MOVE THE MAINTENANCE PIPELINE TO THE MIDWEST

Another idea would be to move the entire pipeline to somewhere in the Midwest like Iowa or Nebraska. These people are losing their livelihood and have never received much benefit from defense dollars. They know how to work hard and they are good at repairing farm machinery. They would be naturals for missile maintenance.

G. EARLY ELIMINATION OF OLDER MISSILES

One way of obtaining more storage and production capacity would be to eliminate the need for some of it. This could be done by early retirement of missile types that are scheduled to be phased out. These weapons are no longer needed because they have either become obsolete or something better has been developed. Until they are removed from the system they will continue to be a drain on the maintenance pipeline's resources. These missiles could be disposed of or perhaps sold through Foreign Military Sales.

H. DRAW ON OTHER RESOURCES

One way to reduce the workload on the Navy's maintenance pipeline would be to use other resources such as the Army's or the Air Force's capabilities. The Army and Air Force inventories contain some of the same missiles as the Navy. Perhaps there is some excess capacity available which could be used by the Navy.

The Air Force places its intermediate maintenance facilities at the same locations as its organizational maintenance. Every base that has aircraft which carry missiles has an intermediate facility for maintaining missiles. Some of these bases are located in the Philippines, West Germany, and other North Atlantic Treaty Organization (NATO) countries. If these facilities could be used to repair some of the Navy's missiles, it would improve the asset readiness and eliminate large amounts of time that are consumed returning the weapons to the U.S. Though there would be administrative problems to be worked out, this arrangement could be beneficial to both services. Navy missiles could be kept separate from Air Force missiles to reduce some of the accounting problems.

I. USE CONTRACTORS TO REPAIR THE MISSILES

An alternative idea would be to have contractors perform this maintenance. It could be cost effective to contract out the work rather than to continue the present practice. The contractors are the most capable of repairing the missiles that are new or have received a major modification because of their greater experience. There are often problems when the Navy assumes the maintenance functions due to lack of spare parts and qualified people to repair the missiles, as well as shortages of facilities.

J. INCREASED ROLES

The role that the Naval Aviation Logistics Center (NALC) plays could be expanded. Current responsibilities of the NALC ensure that the NARFs support the depot repair programs in assigned areas. They provide support to the NARFs in training, equipment and facility acquisition, quality assurance, engineering investigation services, and reliability. Perhaps better use could be made of their knowledge of Naval Aviation logistics. [Ref. 10: p. 1-1-6]

Another resource that might be used are the students and staff at the Naval Postgraduate School. There is a good supply of knowledge and manpower to draw from. Perhaps the missile maintenance pipeline could be used as a continuing case study for the logistics curriculum at the school.

VI. SUMMARY

A. GENERAL

The primary objective of this report is to determine if there are opportunities to reduce the length of time that a missile is in the maintenance pipeline. Those opportunities do exist. There are several areas that have great potential including transportation, data management, and production processes. However, no single change appears as a cure-all. A coordinated and well-engineered plan needs to be developed that takes the entire system into consideration.

The current methods of operation for the pipeline were developed with good reason and intention. This may be the most effective missile maintenance program in operation anywhere. However, the tendency of organizations and systems as they grow larger, is to follow their own inertia and become resistant to change. This resistance can lead to overlooking new or different possibilities that did not exist or were not feasible previously.

There are no final conclusions to this report. The recommendations put forth are simply ideas that have potential to assist in reducing missile turnaround time.

B. QUESTIONS TO BE ANSWERED

There are several questions that deserve consideration before changes are made to the maintenance pipeline. They include:

1) How much increased capacity should be built into the maintenance pipeline? Some cushion is required for wartime needs as well as for further growth in the inventory. What needs to be determined is how much additional capacity is desired and in what areas it is necessary. During wartime, obtaining transportation and providing temporary storage would probably not be difficult, but, training production workers and obtaining additional test equipment/test facilities would be.

2) What is an increase in asset readiness worth? Is the value gained by reducing turnaround time measured in monetary terms of the missiles themselves or in the benefit to national defense.

3) Should the transportation system used by the missile maintenance pipeline rely on peacetime resources or expected wartime resources? If it is to be based on wartime resources, as much required transportation as possible should be eliminated.

C. AREAS FOR FURTHER STUDY

There are areas that this report was not able to cover in sufficient depth where further study would be warranted. These areas are:

1) Systems with similar maintenance programs such as jet engines or torpedoes. These programs may have faced similar challenges and found ways of resolving them. A comparison study could be done to determine how similar programs deal with change.

2) The depot level maintenance process at contractor and Navy DOPs. This area should be examined to determine delays, bottlenecks, and limitations at that maintenance level.

3) The dedicated transportation system for HARPOON. Determine the results which have occurred after the initial reduction in turnaround time. Has there been continued improvement? Is the improvement because of the transportation or some other factor? Has the transportation been cost effective? Would dedicated transportation be effective for another program such as PHOENIX?

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