AD NUMBER
AD488616
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AD No. 488616
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HumRRO

U.S. Army Air Defense Human Research Unit
Fort Bliss, Texas

Under the Technical Supervision of

The George Washington University
HUMAN RESOURCES RESEARCH OFFICE
operating under contract with
THE DEPARTMENT OF THE ARMY

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(6) A SURVEY OF ORGANIZATIONAL MAINTENANCE OF THE NIKE AJAX MISSILE .

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RESEARCH MEMORANDUM
(11) Ju[redacted]60
(12) 73p.

Subtask MAINTRAIN III

The study on which this report is based was conducted under Subcontract No. HumRRO-1-002 between the Human Resources Research Office and the American Institute for Research. Dr. Robert A. Goldbeck and Dr. Emanuel Kay of the American Institute for Research served as Project Director and Associate Project Director, respectively. Dr. Robert Glaser, American Institute for Research, was the principal investigator and Dr. Murray Glanzer, also of AIR, was the research adviser. The subcontractor's report, prepared by Dr. Goldbeck and Dr. Kay, was revised to the form presented here by Dr. James P. Rogers, Jr., of the U. S. Army Air Defense Human Research Unit and by Dr. W. L. Williams, Jr., also of the Air Defense Human Research Unit, who was the subcontract monitor. Monitoring of the subcontract was conducted under the supervision of Dr. Joseph C. Hammock, formerly Director of Research, Air Defense Human Research Unit.

CONTENTS

A SURVEY OF ORGANIZATIONAL MAINTENANCE
OF THE NIKE AJAX MISSILE

OBJECTIVE

Previous HumRRO research[1] in the area of maintenance of complex weapon systems has tended to concentrate on fire control system maintenance. Furthermore, such research has generally been restricted to one particular MOS engaged in maintaining a given fire control system. This research orientation had not provided research coverage of missile maintenance per se or of maintenance problems where several different MOS's share the maintenance responsibility for an entire system or a large portion of one system. This study should be regarded as the first step in providing such coverage and is intended to provide further insights into the general problems of maintenance training.

The NIKE AJAX missile and the battery level personnel who maintain it and its associated equipment were selected as research vehicles, because, at the time the study began, there were no other operational Army Air Defense missiles. By studying the organizational maintenance of the NIKE AJAX missile, in terms of the activities

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[1] HumRRO Subtask RADAR IV: The AAFCS M-33 Mechanic Proficiency Test.

HumRRO Subtask RADAR VI: Development and Evaluation of an Experimental Program of Instruction for Fire Control Technicians.

HumRRO Task ACHILLES: The Development and use of a Performance Test as a Basis for Comparing Technicians With and Without Field Experience: The NIKE AJAX IFC Maintenance Technician.

HumRRO Subtask MAINTRAIN I: Further Evaluation of an Experimental Program of Instruction for AAFCS M33 Fire Control Technicians required for effective maintenance and in terms of the distribution of the NIKE AJAX missile MOS's among the various maintenance activities, it was expected that information of value to maintenance researchers, the Air Defense School and other operational agencies could be provided.

Specifically it was expected that information could be provided that would be helpful with respect to the following problem areas:

(1) The evaluation and modification of training for personnel who maintain the NIKE AJAX missile;

(2) The allocation of personnel to the several aspects of NIKE AJAX missile maintenance; and

(3) The development of procedures for more effective maintenance and maintenance training for complex weapon systems in general.

It was not expected that definitive solutions for these problems would be provided, but that some information would be of immediate operational utility, and some would suggest and provide the basis for further research.

DESCRIPTION OF RESEARCH VEHICLE

The purpose of this section is to describe the physical characteristics and functional organization of that portion of a NIKE AJAX battery relevant to this study.

Physical Characteristics of the Launching Area

Each NIKE battery has two physically separate areas, the Battery Control Area and the Launching Area. The Battery Control Area contains the radar and communication equipment used to coordinate a NIKE engagement. The Launching Area contains the facilities for preparing missiles for firing, for storing prepared missiles, and for launching missiles. Its major function is to have NIKE rounds "ready to go" at any time designated by the Battery Control Area. In order to achieve this state of readiness, the Launching Area is provided with appropriate facilities, tools, and personnel.

The major units of the Launching Area which are the concern of this study are (1) the assembly area and (2) the launcher area.[1]

The primary function of the assembly area is the conversion of newly received missiles into ready rounds which can be quickly prepared for firing by the launcher personnel. To achieve this end the assembly area contains an assembly building and an out-of-doors revetted area. The assembly building houses most of the equipment

[1] The reader should note that the launcher area is contained within the Launching Area. For purposes of clarity, launcher area is written with lower case letters and Launching Area is capitalized in this report.

needed for assembling and checking out missiles. Such potentially dangerous operations as fueling, oxidizing, and warhead installation are done in the revetted out-of-doors area.

The primary function of the launcher area is to provide facilities for the storage and launching of missiles. These facilities include as many as four firing sections (each consisting of an underground storage area, firing panel, and above ground launcher-loader assemblies) and the Launcher Control Trailer (LCT) which contains a control console and the test responder.

Functional Organization in the Launching Area

The maintenance of equipment in the assembly and launcher areas and the preparation and maintenance of missiles are the responsibility of the Launching Area personnel. The Launching Area Platoon Leader (MOS 1180) has over-all command of the Launching Area.

1. Assembly Area Personnel

The assembly area personnel are responsible for preparing missiles and for maintaining assembly and servicing equipment and missiles. Men with the following MOS's are assigned to and perform a large portion of their work in the assembly area.

MOS 1182 - Surface-to-Air Missile Material Assistant, NIKE (formerly MOS 1185 and frequently referred to as the Missile Warrant Officer)

MOS 223 - Air Defense Missile Electronics Mechanic (NIKE AJAX)

MOS 172 - Air Defense Missile Materiel Mechanic (NIKE AJAX) (formerly MOS 221)

MOS 624 - Powerman (formerly MOS 351)

MOS 357 - Guided Missile Installation Electrician

MOS 612 - Construction Machine Operator

In ten batteries represented in this study the average number of the assembly area MOS's was as follows:

MOS	Average for Battery
1182	1.0
223	2.5
172	2.2
624	2.0
357	3.3
612	1.0

The 1182 is in charge of the assembly area. The 223 is an electronics specialist who has many important maintenance responsibilities. The 172 also has important maintenance responsibilities although of a less complex nature than those of the 223. The MOS's 624, 357, and 612 offer support services to the 223 and 172, but occasionally become involved in independent maintenance activities. The MOS's 223 and 172 will receive the greatest amount of attention in this study since they have the most critical maintenance responsibilities in the Launching Area.

2. Launcher Area Personnel

Launcher area personnel are assigned to firing sections and to the LCT. Each of the four firing sections is supervised by a section chief (usually the highest ranking NCO) and is manned by operator personnel. Operator personnel also are assigned to the LCT. The MOS's in the launcher area are as follows:

MOS 171.1-6 - Air Defense Missile Crewman (NIKE AJAX) (formerly MOS 225)

MOS 171.0 - Air Defense Missile Crewman (NIKE AJAX) (formerly MOS 220)

In ten batteries the average number of the launcher area MOS's was as follows:

MOS	Average for Battery
171.1-6	14.1
171.0	24.4

Although the launcher area personnel are concerned mostly with operating the equipment, they also become involved in maintenance and therefore need to be considered in a study of Launching Area maintenance responsibilities. There are two ways in which these personnel become involved in maintenance. First, they are assigned the responsibility for periodic checks of equipment and missiles. Second, they are in the best position to observe indications of malfunction that occur while equipment is being operated.

In contrast to the average battery launching area strengths reported above, authorized strengths for these MOS's, as obtained from Table of Organization and Equipment Nr 44-147D, 5 September 1957[1] are shown in Table 1.

Table 1

Authorized MOS Strength at Time of Data Collection

Authorized Strength	MOS							
	1182	223	172	624	357	612	171.1-6	171.0
(full)	1	7	7	2	1	1	24	45
(reduced)	1	6	6	2	1	1	17	33

It is evident that the batteries studies were significantly understrength with regard to the MOS's 223, 172, 171.1-6, and 171.0.

RESEARCH METHOD

Previous research related to the NIKE AJAX system had provided researchers with a substantial knowledge of the characteristics of the system and, in general terms, of the capabilities and assignments of personnel manning the system at US ARADCOM sites. The background of knowledge thus provided convinced the research personnel who undertook the present study that its purposes could be adequately and most economically served by concentrating observation and data collection

[1] The data discussed in this study were collected in 1957

efforts on relatively few conveniently accessible US ARADCOM batteries.

Data were collected from a total of 21 batteries. The assignment of these batteries to higher echelon units was such that the policies and SOP's of seven US ARADCOM battalions, three US ARADCOM groups, one US ARADCOM brigade and two US ARADCOM regions could be reflected in battery level operations.

In order to minimize interference with normal battery operations, various subgroups of these 21 batteries were utilized as data collection points for the various aspects of battery maintenance activites.

The general approach of this study was to use job activity data to form a comprehensive picture of what site personnel are required to do.

Collection of the Data

As a result of direct observations of on-the-job activities of Launching Area personnel and of interview sessions with these personnel, it was determined that Launching Area personnel perform three major types of maintenance activities: (1) Missile Assembly and Servicing, (2) Preventive Maintenance, and (3) Trouble Analysis and Repair. The data collection procedures and instruments for each of these types of maintenance activity will be discussed in turn.

1. Missile Assembly and Servicing

The amount of this work which needs to be done at any given time shows wide variations. The arrival of new missiles at a site results in a heavy concentration of available personnel on assembly activities. Field changes and repairs will also result in a heavier than normal commitment of personnel to this work.

On the basis of an examination of NIKE manuals, missile assembly checkout sheets, and direct observation of missile assembly and servicing procedures, the complete assembly and servicing job was divided into eight job segments. Each segment represents a discrete portion of the assembly procedure and consists of relatively homogeneous job activities. Each of the eight job segments was further subdivided into subtasks. In order to determine the assigned responsibilities for each of the 52 subtasks thus established, a special questionnaire was developed. This questionnaire the Launching Area Maintenance Job Survey (LAMJS),[1] asked four questions: (1) MOS's usually performing each subtask; (2) MOS's usually assisting in performance of each subtask; (3) MOS's who usually supervise the performance of each subtask; and (4) MOS's who have also performed the subtask. This questionnaire was completed by Missile Warrant Officers (MOS 1182) in ten batteries.

2. Preventive Maintenance

Preventive maintenance consists of the periodic checks of ready missiles and Launching Area equipment. The checks, which are described in greater detail in later sections of this report, vary in

[1]In addition to the questions listed here, several other questions covering other aspects of the maintenance job appeared on the questionnaire. These questions and the data resulting from them will be discussed in a later section of this report.

length and complexity. Both launcher and assembly area personnel perform these checks.

To obtain information on preventive maintenance, questions about these activities were included in the questionnaire mentioned above. For the checks judged to be most important, the batteries were asked to state the MOS's who (1) usually performed, (2) usually assisted in performing, (3) had also performed, and (4) supervised each check.[1] For the remaining checks, the batteries were asked to state who performed the checks. Additional information was obtained from an examination of the preventive maintenance check sheets which are regularly completed during the performance of periodic checks. Thus it was possible to determine both the content of each check and the malfunctions encountered. These data were obtained from ten batteries.

3. <u>Trouble Analysis and Repair</u>

Malfunctions which require analysis and repair can occur at any time during the course of periodic checks, drills, and other operation of the equipment.

Data on some of the more involved malfunctions were obtained from an examination of Status of Defense Reports (SOD Ports), a standard Army form. These reports list malfunctions which degrade the operational readiness of a battery. In general, malfunctions are included on these reports only if they require more than one day to diagnose and correct. Quite often the correction of these

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[1]For individual checks, Missile Warrant Officers completing these forms could indicate the assignment of varying responsibilities to several individuals within the same MOS.

malfunctions requires Ordnance support or the requisitioning of parts. SOD Ports were obtained from eight batteries.

A second source of data on trouble analysis and repair activities was the aforementioned questionnaire. In addition to the questions on Missile Assembly and Servicing and on Preventive Maintenance, this questionnaire contained questions on common malfunctions. The Missile Warrant Officers who completed this instrument were asked to list the most common malfunctions encountered in 11 equipment categories and to state whether or not site personnel repaired each of these malfunctions. A description of the equipment categories and of the malfunctions reported will be presented later in this report.

A third source of trouble analysis and repair data was the Malfunction Record (MR). This form was developed for use by battery personnel in keeping a record of malfunctions encountered during a three-week period. During this period, battery personnel recorded for each malfunction: (1) the MOS making the diagnosis; (2) time required for the diagnosis; (3) the MOS making the repair; and (4) time required for the repair. Six batteries completed one MR each, and six additional batteries completed two MR's each. Thus, the data obtained represent 54 battery weeks.

In addition to the three sources of malfunction data discussed above, a fourth form was utilized. This form, the Trouble Analysis Behavior Survey (TABS), was designed to provide a comprehensive picture of the steps taken by site personnel in isolating and correcting malfunctions. The TABS listed 583 malfunction indications which can occur in launcher and assembly areas. For each of these malfunctions, site personnel were asked to state the steps they would take in isolating the source of the trouble, and to state whether or not site personnel could make the necessary repairs.

RESULTS

This section of the report describes the maintenance activities of the NIKE AJAX launcher and assembly area personnel. For convenience, the findings have been grouped according to the three major job categories: (1) Missile Assembly and Servicing, (2) Preventive Maintenance, and (3) Trouble Analysis and Repair.

Missile Assembly and Servicing Activities

Missile assembly and servicing is an important activity of the Launching Area. The readiness of the battery to fulfill its ultimate mission depends to a large degree on this activity. The success of this work depends on the contributions made by a number of MOS's. To determine the part which each of the Launching Area MOS's plays in performing this work, different kinds of job responsibility were analyzed for the various segments of assembly and servicing work.

1. Primary Responsibility

The primary responsibility among the MOS's for the assembly and servicing work was determined from the answers to the questions, "Who usually does this job", and "Who else has done this job?", in the LAMJS. Ten batteries answered these questions about each of the 52 subtasks which constitute the assembly and servicing procedure. Table 2 summarizes the answers to these questions. A double asterisk (**) indicates that three or more batteries reported that a particular subtask is usually performed by the indicated MOS and a single asterisk (*) indicates that three or more batteries reported that a particular subtask has been performed by the indicated MOS

An examination of Table 2[1] reveals that in general the MOS's 172 and 223 were reported as performing most of the assembly and servicing activities. As might be expected it may be seen that the 223 is reported most frequently as performing the job segments which are heavily loaded with electronic subtasks, while the 172 is reported most frequently as performing those job segments which are heavily loaded with mechanical subtasks. The 171.1-6 has a primary responsibility role in the launcher area (activity VIII in Table 2).

2. Support Roles

In addition to assuming primary responsibilities for certain work tasks, the MOS's also assist each other. The support roles played by the MOS's were determined from the answers to the question, "Who usually assists in performing this job?" in the LAMJS.

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[1] These data present a picture of current (at the time of the study) and past practice with regard to the assignment of MOS's to assembly and servicing functions. Although a composite picture of "who does - or has done - what" could be formed by combining these date, they have been treated separately to show the shift in assignment practice, especially with regard to MOS 223.

Table 2

MOS Responsibility for the Performance of Assembly and Servicing Activities

Activity	172	223	1182	171.1-6	171.0	612	624	357
I. Receiving, Uncrating, and Inspection								
1. Inspects and depressurizes missile container and inspects booster container	**	*						
2. Attaches hoist beams to missile or booster	**	*			**			
3. Positions and operates hoist	**	*				**		
4. Inspects missile booster, fins, and attached parts	**	*				*		
5. Makes log entries		**	**					
6. Performs booster wiring test	**	**		*				

** Currently performs
* Has performed

Table 2 continued

Activity	172	223	1182	171.1-6	171.0	612	624	357
II. Mechanical Systems Test								
1. Propulsion Plumbing Test: checks tank pressures and depressurizes tanks	**	**						
2. Removes surface portions and fittings	**	**			*			
3. Checks missile air pressure lines and valves	**	*						
4. Connects capping compressor to missile	**	*				**		
5. Operates capping compressor				*		**		
6. Performs propellant system and hydraulic system high pressure leak tests	**	**						
7. Depressurizes propellant and hydraulic air tank	**	**						

Table 2 continued

Activity	172	223	1182	171.1-6	171.0	612	624	357
III. Missile Assembly								
1. Attaches main fins and ailerons and control fins	**	**						
2. Adjusts control fins by use of potentiometer centering bridge		**						
3. Removes battery box		**			**			
4. Installs battery		**						
5. Checks guidance section pressure and depressurizes	**	**						
IV. Complete Missile Checkout: Connects and Operates Test Equipment as Follows:								
1. Missile hydraulic test stand		**						
2. Missile electrical test set		**						

Table 2 continued

Activity	172	223	1182	171.1-6	171.0	612	624	357
3. Missile r-f test set		**						
4. R-f test saddle		**						
5. Stagnation pressure pump		**			*			
6. Guidance section blower	*	**						
V. Missile Booster Joining								
1. Prepares launching rail for booster and secures booster to rail	**	**						
2. Places booster on rail with hoist beam	**	*						
3. Attaches missile hoist and beam to missile (using missile-booster joining hoist)	**	*			**			
4. Prepares rail, positions and secures missile	**	*						

Table 2 continued

Activity	172	223	1182	171.1-6	171.0	612	624	357
5. Positions trailer (Driver)				**	**			
6. Loads and secures rail on trailer	**	**			**			
VI. Propellant Servicing								
1. Positions trailer to fuel position (Driver)		*		**		**		
2. Prepares fuel and equipment	**	*						
3. Prepares missile for fueling	**	*						
4. Fuels missile	**	*						
5. Prepares missile for oxidizing	**	*						
6. Prepares oxidizer and equipment	**	*						

Table 2 continued

Activity	172	223	1182	171.1-6	171.0	612	624	357
7. Fills missile with oxidizer	**	*						
VII. Warhead System Installaticn								
1. Tests arming mechanism	*	**						
2. Installs arming mechanism	**	**						
3. Installs leads	**	**						
4. Installs warheads	**	*		*				
5. Inspects detonating cord assembly	**	**		*				
VIII. Transporting to the Launcher; Final Preparation								
1. Transports and transfers missile to launcher	**	*		**	**			
2. Makes final detonating cord connections to arming mechanism		*		**				

Table 2 continued

Activity	172	223	1182	171.1-6	171.0
3. Connects ground power plug to electrical disconnect plug	*	*		**	**
4. Connects quick-disconnect plug to quick-disconnect plug receptacle		*		**	**
5. Attaches hydraulic actuating lanyard to the quick-disconnect plug	**	*			
6. Attaches propellant system activating lanyard	**	*		**	**
7. Performs electrical test on igniter		**		*	
8. Installs igniter in booster	**			**	
9. Attaches booster fins				*	**
10. Inserts starting mix (slugging)	**	**		**	
TOTAL **	33	25	[illegible]	[illegible]	10
TOTAL *	3	23		6	2

The MOS's 172 and 223 were seldom reported as assisting because they usually assume primary responsibility for the performance of the various tasks. No more than two batteries reported the 171.1-6 as assisting on any subtask. In general, the 171.1-6 does not play a large role as an assistant during assembly and servicing nor does the small role which he does have seem limited to a specific area or set of functions.

The 171.0 was reported as assisting in the performance of almost all subtasks.

The 612 is utilized by no more than three batteries for any subtask, but the subtasks for which he is mentioned tend to represent specific kinds of functions with a concentration of reports in the mechanical tests job segment. Except for the actual performance of the leak test, he is mentioned for every subtask in this job segment. During the assembly job segment, the 612 is mentioned as assisting in the mechanical subtasks but not for the battery installation or for the centering of the fins. The 612 is mentioned as assisting in all of the booster joining subtasks, in all of the warhead installation subtasks, and in four final preparation subtasks. The latter four subtasks deal with driving the trailer and connecting ground power plugs and the arming mechanism. Thus, it would seem that the 612 has a limited but somewhat specific function, as an assistant, in the performance of various mechanical subtasks.

The 624 was reported as assisting in the performance of assembly and servicing subtasks which are mechanical in nature.

The 357 was reported as assisting in five subtasks involving operating the capping compressor and driving the transporter-trailer.

In summary, the 171.0 was reported as having the largest and most general role as an assistant for the assembly and servicing subtasks. This role is suitable because of the availability of a relatively large number of personnel with this MOS and their general lack of special capabilities. The 171.1-6, 612, 624, and 357 seem to have a lesser role as assistants. This may be due in part to the smaller number of these personnel who are available (especially MOS 612 and MOS 624) and the fact that they have other specific functions assigned to them which may limit their general participation in the assembly and servicing work.

3. Supervisory Roles

In addition to actually performing the missile assembly and servicing subtasks, site personnel assume varying degrees of supervisory responsibility for the subtasks. It is important to determine the nature of the supervisory roles because this type of work may require training differing from that normally received for task performance. The supervisory roles played by the MOS's were determined from answers to the question, "Who usually supervises this job?" in the LAMJS. The answers are summarized in Table 3, an asterisk (*) indicating that three or more batteries reported that the indicated MOS usually supervises a particular subtask.

The results in Table 3 show that supervision in the assembly area and in the revetted area is distributed among the 172, 223, and 1182 MOS's, and that supervision in the launcher area (activity VIII in Table 3) is largely the responsibility of the 171.1-6 and the 1182.

Table 3

MOS Responsibility for the
Supervision of Assembly and Servicing Activities

Activity	172	223	1182	171.1-6
I. Receiving, Uncrating, and Inspection				
1. Inspects and depressurizes missile and booster containers	*	*	*	
2. Attaches hoist beams to missile or booster	*	*	*	
3. Positions and operates hoist	*	*	*	
4. Inspects missile booster, fins, and attached parts	*	*	*	
5. Makes log entries			*	
6. Performs booster wiring test		*	*	
II. Mechanical Systems Test				
1. Propulsion Plumbing Test: checks tank pressures and depressurizes tanks	*	*	*	
2. Removes surface portions and fittings		*	*	
3. Checks missile air pressure lines and valves	*	*	*	

Table 3 continued

Activity	172	223	1182	171.1-6
4. Connects capping compressor to missile	*	*	*	
5. Operates capping compressor	*	*	*	
6. Performs propellant system and hydraulic system high pressure leak tests	*	*	*	
7. Depressurizes propellant and hydraulic air tank		*	*	
III. Missile Assembly				
1. Attaches main fins and ailerons and control fins	*	*	*	
2. Adjusts control fins by use of potentiometer centering bridge		*	*	
3. Removes battery box		*	*	
4. Installs battery		*	*	
5. Checks guidance section pressure and depressurizes		*	*	
IV. Complete Missile Checkout: Connects and Operates Test Equipment as Follows:				
1. Missile hydraulic test stand		*	*	

Table 3 continued

Activity	172	223	1182	171.1-6
2. Missile electrical test set		*	*	
3. Missile r-f test set		*	*	
4. R-f test saddle		*	*	
5. Stagnation pressure pump		*	*	
6. Guidance section blower		*	*	
V. Missile Booster Joining				
1. Prepares launching rail for booster and secures booster to rail		*	*	
2. Places booster on rail with hoist beam	*	*	*	
3. Attaches missile hoist and beam to missile (using missile-booster joining hoist)		*	*	
4. Prepares rail, positions, and secures missile	*	*	*	
5. Positions trailer (Driver)		*	*	
6. Loads and secures rail on trailer		*	*	

Table 3 continued

Activity	172	223	1182	171.1-6
VI. Propellant Servicing				
1. Positions trailer to fuel position (Driver)	*	*	*	
2. Prepares fuel and equipment	*	*	*	
3. Prepares missile for fueling		*	*	
4. Fuels missile		*	*	
5. Prepares missile for oxidizing		*	*	
6. Prepares oxidizer and equipment		*	*	
7. Fills missile with oxidizer		*	*	
VII. Warhead System Installation				
1. Tests arming mechanism		*	*	
2. Installs arming mechanism		*	*	
3. Installs leads		*	*	
4. Installs warheads		*	*	
5. Inspects detonating cord assembly		*	*	

Table 3 continued

Activity	172	223	1182	171.1-6
VIII. Transporting to the Launcher; Final Preparation				
1. Transports and transfers missile to launcher		*	*	*
2. Makes final detonating cord connections to arming mechanism			*	*
3. Connects ground power plug to electrical disconnect plug				*
4. Connects quick-disconnect plug to quick-disconnect plug receptacle				*
5. Attaches hydraulic actuating lanyard to the quick-disconnect plug			*	*
6. Attaches propellant system activating lanyard	*		*	*
7. Performs electrical test on igniter				
8. Installs igniter in booster			*	*
9. Attaches booster fins			*	*
10. Inserts starting mix (slugging)	*	*	*	
TOTAL	16	43	45	8

Preventive Maintenance Activities

As part of a standardized preventive maintenance program, all of the Launching Area equipment is checked on daily, weekly, and monthly schedules.

Preventive maintenance check sheets for the major pieces of Launching Area equipment were collected and analyzed in order to obtain an estimate of the number and kind of malfunctions uncovered by these periodic checks. These data are presented in Appendix A and summarized in this section. To determine what responsibilities are assigned to the various MOS's for the different checks, the responses to the Launching Area Maintenance Job Survey from ten batteries were summarized for presentation below and in Table 4.

1. Launcher Area Checks

The launcher area checks are performed on the missiles and the major pieces of equipment used in the firing of a missile.

a. The Missile

Since there is no way of actually flight testing the missile, the checking of its continued capability for successful flight assumes considerable importance. Daily, weekly, and monthly checks are scheduled for the missile.

(1) Daily Missile Maintenance Check

Each missile is checked daily for directly visible indications of trouble. The most frequent malfunctions uncovered by the daily checks are concerned with oil

Table 4 (Explanation)

* Entries in the table indicate the number of batteries who assigned check responsibilities to the various MOS's. Although the data represents the practice at ten batteries, the sum of any row in the table does not necessarily equal ten, since a battery could list more or less than one MOS as appropriate to that battery's practice. For individual checks, column totals greater than ten indicate the assignment of varying responsibilities to several individuals within the same MOS.

** The other MOS's indicated by the batteries as having some responsibility for checks are the MOS's 313, 612, 111, 550, and 835.

Table 4

MOS Responsibility for Preventive Maintenance Checks *

CHECK	MOS						
	223	172	1182	171.1-6	171.0	1180	Others **
Launcher Area							
Missile							
a. Missile Maintenance (Daily)							
Usually checked by				5	5		
Usually assisted by				2	7		
Usually supervised by				10		1	
Has been performed by	2	2		1	3		5
b. MTR Lock-on (Weekly)							
Usually checked by				6	2		1
Usually assisted by				2	8		1
Usually supervised by	3		2	6		1	1
Has been performed by	4	2		2	3		1

Table 4 continued

CHECK	MOS						
	223	172	1182	171.1-6	171.0	1180	Others **
c. LOP Battery (Weekly)							
Usually checked by				5	5		
Usually assisted by				2	7		
Usually supervised by	1			10		1	
Has been performed by	4	2		1	3		5
d. Missile RF & Electrical (Monthly)							
Usually checked by	10						
Usually assisted by	3	1		4	2		
Usually supervised by	6		6	1			
Has been performed by	3	2	1		2		
Firing Equipment							
e. Launcher-Loader (Weekly)							
Usually checked by	4	2		4	4		

Table 4 continued

CHECK	MOS						
	223	172	1182	171.1-6	171.0	1180	Others **
f. Launcher & Transporter Rail (Weekly)							
Usually checked by	3	3		4	5		
g. Missile-Booster Storage Rack (Weekly)							
Usually checked by		1		5	5		
h. Launching Control Console (Weekly)							
Usually checked by	3	1		5	2		
Usually assisted by				1	6		
Usually supervised by	5		2	7			1
Has been performed by	3	1		2	2		2
i. Section Control Console (Weekly)							
Usually checked by	2			5	3		
Usually assisted by				1	5		
Usually supervised by	4		2	8			1
Has been performed by	3	1		3	1		2

Table 4 continued

CHECK	MOS						
	223	172	1182	171.1-6	171.0	1180	Others **
Assembly Area							
Test Equipment							
j. RF Test Set (Weekly)							
Usually checked by	10						
k. Hydraulic Test Stand (Weekly)							
Usually checked by	5	6					
l. Propulsion Plumbing Tester (Weekly)							
Usually checked by	2	8					3
Servicing Equipment							
m. Fuel & Oxidizer Servicer (Weekly)							
Usually checked by	2	8		1	1		

Table 4 continued

CHECK	MOS						
	223	172	1182	171.1-6	171.0	1180	Others **
Handling Equipment							
n. Handling Dollies (Weekly)							
Usually checked by	3	7			3		
o. Hoist Beams (Weekly)							
Usually checked by	1	7		1	2		
p. Handling Rings & Yokes (Weekly)							
Usually checked by	1	8			2		
q. Joining Hoist (Weekly)							
Usually checked by	1	7		1	2		
r. Transporter-Trailer (Weekly)							
Usually checked by	2	4		1	3		4

and air leaks, lanyard tightness, and missing flags. In general, the number of malfunctions uncovered by this check is relatively small. The responsibility for performing this check was reported as being distributed among MOS's as shown in Table 4, item a. As can be seen from this table execution of the daily check is primarily the responsibility of the 171.1-6 and 171-0 with the 171.1-6 also having the responsibility for supervision. This check was indicated as also being performed by the 172 and 223, but not with sufficient frequency to suggest that these MOS's generally have major responsibility for this activity.

(2) Weekly Missile Maintenance Check

The weekly check on the missile is concerned with the "lock on" by the missile tracking radar (MTR), a battery test at the launcher operating panel (LOP), and the overboard dump port valve. The "lock on" by the MTR is performed by sending commands from the battery control area to the missile while it is in an erect position on the launcher. The section control panel operator monitors indicators on his panel and reports from a crewman who observes fin responses of the missiles. The battery test at the LOP consists of checking the missile battery by means of meters provided on the LOP. The overboard dump port valve check is a visual check made to insure that the valve is cocked.

The maintenance check responsibilities for the MTR "lock on" and LOP battery checks were found to be distributed among the MOS's as shown in Table 4, items b. and c. It is seen that the 171.1-6's and 171.0's have primary responsibility for the execution of weekly missile checks with the 171.1-6 again exercising a supervisory responsibility. All of the malfunctions reported were concerned with the MTR check and they were found to occur in approximately 4% of the checks made.

(3) Missile Monthly Maintenance Check

This check consists of a review of the daily and weekly check sheets, an RF checkout, the removal and cleaning of the battery, the cleaning of the battery box, and a check on fuel leaks by means of a sniff test. The sniff test produced four indications of malfunction in 297 monthly checks for 81 missiles. The RF checkout, which is the major part of the monthly check, is described in the next section.

(4) Missile Monthly RF Checkout

This check is an abbreviated version of the RF and electrical check which is performed when the missile is assembled. It is performed at the launcher with a portable RF and electrical test set. The distribution of responsibilities among the MOS's for this check is shown in Table 4, item d. The 223 has the primary responsibility for this check. He shares the supervision of the check with the 1182.

It is noteworthy that in contrast to the daily and weekly missile checks which are performed by the launcher personnel, the monthly RF checkout is primarily the responsibility of the 223 technician. While no indications of out-of-tolerance missile current were found during the weekly checks, these out-of-tolerance indications were reported for 37% of the monthly RF checks.

The two next most frequent malfunctions reported during the RF monthly checkout were for missile voltage and response time. The missile voltage malfunctions occurred in approximately 14% of the checks made and the response time malfunctions occurred in approximately 5% of the checks made.

b. Firing Equipment

(1) Weekly Launcher-Loader Maintenance Check

The launcher-loader assembly includes the hydraulic erection system, missile test package, and electrical junction box. The launcher hydraulic erection system and the missile testing hydraulic power package checks consist of operating the units to determine adequacy of operation, checking for correct fluid level, pressure, valve positions and looking for evidence of leaks. The junction box is checked by examining it for evidence of damage and determining that its voltage distributing and feedback functions are accomplished. Table 4, item e. summarizes the maintenance check responsibilities for the launcher-loader assembly check. These checks for the launcher-loader were found to be evenly distributed among the assembly area and launcher section MOS's.

The most frequent malfunction encountered during this check was in the launcher operating panel. This malfunction was encountered in approximately 4% of the checks made. All other malfunctions occurred 1% of the time or less.

(2) Weekly Launching and Transporter Rail Maintenance Check

The rail is used as a supporting and handling unit for the complete NIKE round during storage, transit, loading, testing, erecting, and launching. During the check the physical condition of the rail and its moving parts, and the hydraulic and electrical lines and connections are examined. The maintenance check responsibilities for the launching and transporter rail were distributed among the MOS's as shown in Table 4, item f. The responsibility for this check is distributed among the assembly area (223, 172) and section MOS's (171.1-6, 171.0). The malfunctions which are reported occur in less than 10% of the checks made.

(3) Weekly Missile-Booster Storage Rack Maintenance Check

During the weekly check of the storage rack, the frames are examined for rust or damage, and the pins are visually checked for rust and proper lubrication. Table

4, item g, shows the MOS's responsible for this check. The section personnel, 171.1-6's and 171.0's, have the major responsibility for the check on the storage rack. Truss frame malfunctions were mentioned in approximately 43% of the checks made. Other malfunctions were mentioned in approximately 3% or less of the checks.

(4) Weekly Launching and Section Control Consoles Maintenance Check

The weekly check of the control consoles consists of visually inspecting the physical condition of these units including switches and indicator lights. The responsibility for performing these checks was distributed as shown in Table 4, items h. and i. Major responsibility for performing these checks lies with the operator personnel. Supervision is assigned most frequently to the 171.1-6 with the 223 also having some responsibility for this function. Faulty switches, lights, and missing fuses accounted for the preponderance of malfunctions found.

A review of the responsibilities for checking the firing equipment shows that the technical personnel

(MOS's 223 and 172) are frequently reported by the batteries as performing these checks, although these technicians are more frequently found in the assmelby area.

2. Assembly Area Checks

The checks considered under this heading are all performed on the testing, servicing, and handling equipment which is used in the assembly area.

a. Test Equipment

(1) Weekly RF Test Set Maintenance Check

During this check the RF Test Set is examined for excessive wear, damage, and dust, and is calibrated. The maintenance check responsibilities for the RF Test Set were found to be distributed among the MOS's shown in Table 4, item j. The 223 is responsible for the maintenance check of the RF Test Set. The most frequent malfunctions reported were concerned with the visible condition of the interior of the set. This item was mentioned in approximately 6% of the checks made. The air filters were mentioned in approximately 4% of the checks. All other items were mentioned in 2% or less of the checks made.

(2) Weekly Hydraulic Test Stand Maintenance Check

During this check the hydraulic test stand is examined for evidence of wear, damage, and dirt. The oil level is checked visually. The pressure level and operation of the solenoid valve are checked by operating the set. Table 4, item k. shows the distribution of responsibility for the maintenance check and repair functions. The 223's and 172's share in the maintenance check responsibilities for the hydraulic test stand. No malfunctions were reported for this piece of equipment.

(3) Propulsion Plumbing Tester

The weekly check of the tester consists of examination for signs of damage, dirt, and wear. The motor cut-out is checked by operating it. The maintenance check and repair responsibilities were distributed among the MOS's as shown in Table 4, item 1.

The 172 has the major responsibility for checking the propulsion plumbing tester. No malfunctions were reported for this piece of equipment.

It is clear that the technicians are given full responsibility for checking the test equipment which they use in the assembly area. In no case were the operator personnel (MOS's 171.1-6 and 171.0) reported as performing these checks. Only for the propulsion plumbing tester were other personnel (MOS's 357 and 612) given some responsibility for the checks.

b. Servicing Equipment

(1) Weekly Fuel and Oxidizer Servicer Maintenance Check

The fuel and oxidizer servicer is checked for damage, wear, and dirt. The moving parts are operated to check for freedom of movement. The maintenance check responsibilities were found to be distributed among the MOS's as shown in Table 4, item m. The 172 has the major share of the responsibility for checking the fuel and acid servicer. The malfunctions reported occur in approximately 2% of the cases for each category in which malfunctions are reported.

c. Handling Equipment

(1) Weekly Missile, Guidance Section, Booster, and Universal Dolly Maintenance Checks

During the weekly checks of the dollies, they are examined for damage, wear, dirt and missing parts. The operation of wheels, casters, and brakes are checked. Table 4, item n. shows the maintenance check and repair responsibilities for the four dollies. The 172 has the major responsibility for checking the dollies. The malfunctions reported occur in less than 1% of the checks made.

(2) Weekly Missile and Booster Hoist Beam Maintenance Checks

The missile and booster hoist beam links and pin assemblies are examined visually. The distribution of maintenance check responsibilities for the hoist beams is shown in Table 4, item o. The 172 has the major maintenance check responsibilities for the missile and booster hoist beams. The malfunctions reported in this check occur in approximately 5% of the checks made.

(3) Weekly Missile Handling Rings and Warhead Handling Yoke Maintenance Checks

During the weekly checks of the missile handling rings and warhead handling yoke, the links, pins, and chains are visually examined and the pieces of equipment are examined for condition of paint and for dirt. The maintenance check responsibilities were found to be distributed among the MOS's as shown in Table 4, item p. The 172 has the major responsibilities for the maintenance check for the missile handling rings and for the warhead handling yoke. Malfunctions were discovered in less than 3% of the checks made.

(4) Weekly Booster Joining Hoist Maintenance Check

The booster joining hoist is examined for condition of paint, for dirt, and for bent, cracked or broken parts. The pulleys, winch drum, and wheels are checked for freedom of movement and ease of operation. The wire rope is checked for rust and possible breaks. The maintenance check responsibilities were found to be distributed among the MOS's as shown in Table 4, item q. The 172 has the major responsibility for the check of the booster joining hoist. Only one malfunction was reported in the 54 checks made.

(5) Weekly Transporter-Trailer Maintenance Check

The transporter-trailer is checked for oil leaks, over-all physical condition and for the condition of its appurtenances. The maintenance check responsibilities were found to be distributed among the MOS's as shown in Table 4, item r. The maintenance check function is shared by the personnel in the assembly area and motor pool.

The servicing and handling equipment confirm the division of responsibility set up between the launcher and assembly areas in that the technicians are given major responsibility for the checks. However, the operator personnel, primarily the MOS 171.1-6, are reported as having some responsibility for the checks. This finding probably reflects the relatively simple nature of these checks (see Appendix A) and the resulting reduction in the need for technical skill.

Trouble Shooting and Repair Activities

Batteries have to be ready to carry out their mission at all times. Malfunctions interfere to varying degrees with this requirement. Some malfunctions impair the operational readiness only slightly while other malfunctions cause the battery to be declared temporarily out-of-action. It is, therefore, important that malfunctions be diagnosed and repaired as quickly as possible. Both site personnel and Ordnance support groups share in the work of diagnosis and repair, but within equipment and supply limitations, the batteries strive to be as self sufficient as possible.

In order to study this aspect of the maintenance job, the nature and frequency of the on-site trouble diagnosis and repair activities were determined by three methods.

(1) Estimates of the frequency with which different kinds of malfunctions occur were obtained in the Launcher Area Maintenance Job Survey (LAMJS).

(2) A record of malfunctions encountered on-site for a period of 54 battery-weeks was obtained by use of the Malfunction Record (MR).

(3) Status of equipment reports (SOD Ports) provided a record of malfunctions encountered by two battalions for a four-month period.

Details concerning each of these methods have been presented in the Research Method Section. The findings for each will now be presented and discussed in detail.

1. Estimates of Common Malfunctions - Launcher Area Maintenance Job Survey (LAMJS)

The LAMJS was completed by 10 Missile Warrant Officers at 10 batteries. For each equipment category, the Missile Warrant Officer was asked to list the common malfunctions encountered by his battery and to indicate whether they were repaired by battery personnel. Table 5 gives a summary of their 241 responses to these categories.

As can be seen from the table, it is estimated that 63% of all the common malfunctions cited are repaired by site personnel, 29% are not repaired by site personnel and 8% are sometimes repaired by site personnel. The preceding distribution of repair functions shows a high degree of self sufficiency but is still estimated that approximately 3 out of 10 "common" repairs require Ordnance assistance.

Comparison of the equipment categories by frequency of malfunctions reported shows the launcher-loader assembly and the launcher and section control consoles to have the largest number of estimated malfunctions. These are followed in order by the missile RF and electrical system and the test responder, miscellaneous missile parts, missile air system, missile oil system, miscellaneous LCT equipment, test equipment, assembly and servicing equipment, missile warhead system, and the missile propulsion system. The frequency of malfunction data obtained from the LAMJS will be compared with similar data from the MR and SOD Ports later in this section.

Table 5

Common Malfunctions Reported for the Equipment Categories

Equipment Category	Number Reported	Repaired by Site Personnel		
		Yes	Sometimes	No
1. Missile Air System	23	9	3	11
2. Missile Oil System	21	13	0	8
3. Missile Warhead System	9	5	0	4
4. Missile Propulsion System	3	2	0	1
5. Missile RF & Electrical System and Test Responder	33	21	0	12
6. Miscellaneous Missile Parts	25	18	2	5
7. Launcher and Section Control Consoles	42	35	3	4
8. Miscellaneous LCT Equipment	19	13	2	4
9. Launcher-Loader Assembly	42	28	7	7
10. Test Equipment	13	3	2	8
11. Assembly and Servicing Equipment	11	4	0	7
TOTAL	241	151	19	71
PERCENT	100	63	8	29

2. <u>Reports of Actual Malfunctions-Malfunction Record (MR)</u>

Eighteen MR's were completed and returned by twelve batteries. Six of the batteries returned one form (covering a three-week period) while six others returned two forms (covering a six-week period). These forms provide a record of malfunctions encountered during the reporting period and also indicate the MOS making the diagnosis and repair as well as the time required for each of these activities. The malfunctions were classified into the eleven equipment categories listed above.

Table 6 gives a summary of the diagnosis and repair activities of site personnel. It contains the number of malfunctions reported for each of the eleven equipment categories, the number of these malfunctions which were diagnosed by site personnel, and the number which were repaired by site personnel.

As can be seen from Table 6, site personnel diagnosed 93% of their reported malfunctions and repaired 51% of malfunctions reported, 55% of malfunctions diagnosed by the battery and 53.5% of all malfunctions repaired.

The 172 diagnosed and repaired malfunctions in four equipment categories: (1) the missile air system; (2) the missile oil system; (3) miscellaneous missile parts; and (4) the launcher-loader assembly. He diagnosed 16% of the reported malfunctions and repaired 12.5% of the repaired malfunctions. This suggests that he has the capability

Table 6

Actual Malfunctions Reported on Malfunction Record

Equipment Categories	Total No. Reported	No. Diagnosed by Site Personnel	No. Repaired by Site Personnel *
1. Missile Air System	7	7	1
2. Missile Oil System	17	15	12
3. Missile Warhead System	2	1	1
4. Missile Propulsion System	None reported		
5. Missile RF & Electrical System and Test Responder	51	48	25
6. Miscellaneous Missile Parts	7	7	3
7. Launcher and Section Control Consoles	19	19	15
8. Miscellaneous LCT Equipment	6	7	4
9. Launcher Loader Assembly	71	65	34
10. Test Equipment	7	7	2
11. Assembly and Servicing Equipment	7	7	3
TOTAL	196	183	10[illegible]

* Only 187 malfunctions had been repaired at the time MR forms were collected.

and authority to repair most of the malfunctions which he diagnoses. If diagnosis and repair times can be taken as criteria of difficulty, the malfunctions diagnosed and repaired by the 172 are relatively simple. His median diagnosis time was less than 10 minutes and his median repair time was 30 minutes, with comparatively little variability in either diagnosis or repair times.

The 223 diagnosed and repaired malfunctions in eight equipment categories: (1) RF and electrical system and test responder; (2) launcher and section control consoles; (3) missile warhead system; (4) miscellaneous LCT equipment; (5) launcher-loader assembly; (6) test equipment; (7) assembly and servicing equipment; and (8) miscellaneous missile parts. In general, the diagnosis and repair times for the 223 show considerable variability. Diagnosis times range from zero minutes to four days, with a median time of 15 minutes. The repair time ranged from 5 minutes to 7 days with a median of 30 minutes. Although the 223 diagnosed 64% of all reported malfunctions, he repaired only 38% of the repaired malfunctions. This indicates that the 223 frequently lacks the capability or the authority to make repairs for malfunctions which he has diagnosed.

The 171.1-6 diagnosed malfunctions in six equipment categories: (1) missile air system; (2) missile oil system; (3) missile RF and electrical system and test responder; (4) launcher and section control consoles; (5) launcher-loader assembly; and (6) test equipment. The longest diagnosis time for this MOS was 5 minutes. The 171.1-6 diagnosed 9% of the reported malfunctions. These data suggest that the

171.1-6 diagnoses a wide variety of relatively simple malfunctions. This MOS repaired only 0.5% of the repaired malfunctions.

All other site personnel combined account for only 4% of the diagnoses and 2.5% of the repairs. This indicates that among site personnel only the 172, 223, and the 171.1-6 have appreciable diagnosis or repair functions.

Ordnance was called upon to make only 7% of the diagnoses but made 46.5% of the repairs.

In summary, it appears that site personnel are quite independent in terms of diagnosing malfunctions which they encounter. Three MOS's (172, 223, and 171.1-6) diagnosed 89% of all reported malfunctions and other site personnel diagnosed an additional 4% of the reported malfunctions. In terms of repair functions, however, the site personnel are far from independent. Site personnel repaired only 53.5% of all malfunctions repaired.

3. Report of Actual Malfunctions-Status of Defense Reports (SOD Ports)

Status of Defense Reports were obtained from two battalions and covered the last four months of 1956. The SOD Ports are submitted daily and list the malfunctions which cause battery equipment to be non-operational and the period of time during which the equipment was out-of-action.

Table 7 gives the number of malfunctions reported for each equipment category, the median number of days the equipment in each category was out-of-action, and the range of days the equipment in each category was out-of-action.

As can be seen from Table 7, the eight batteries reported a total of 237 malfunctions during a four-month period. For the eleven equipment areas, the medians for days out-of-action range from two days to twenty-nine days. It is apparent that there are many malfunctions which go beyond the capabilities or authority of site personnel and which tend to reduce the operational capability of the battery.

In terms of frequency of reported malfunctions the launcher-loader assembly ranks highest. It is followed in turn by the missile RF and electrical system and test responder, miscellaneous missile parts, missile oil system, missile air system, test equipment, section and launcher control consoles, missile propulsion system, assembly and servicing equipment, miscellaneous LCT equipment, and the missile warhead system.

4. <u>A Comparison of the Malfunction Data Collection Procedures</u>

Three different methods were used to collect malfunction frequency data. The Launching Area Maintenance Job Survey produced judgments of common malfunction frequency; the Malfunction Record kept by the Missile Warrent Officers produced actual frequencies of malfunctions for a six-week period; and the Status of Defense Reports produced actual frequencies which were reported to a higher headquarters for

Table 7

Actual Malfunctions Reported on Status of Defense Reports

Equipment Category	Number of Reported Malfunctions	Days Out of Action	
		Median	Range
1. Missile Air System	14	2	1-14
2. Missile Oil System	17	3	1-30
3. Missile Warhead System	4	3	3-4
4. Missile Propulsion System	9	3	2-28
5. Missile RF and Electrical System and Test Responder	62	9	1-129
6. Miscellaneous Missile Parts	34	4	1-84
7. Launcher and Section Control Consoles	10	2	0-19
8. Miscellaneous LCT Equipment	4	2	0-22
9. Launcher-Loader Assembly	64	11	1-146
10. Test Equipment	12	10	1-46
11. Assembly and Servicing Equipment	7	29	2-61
TOTAL	237		

a four-month period. It is of interest to examine the comparability of these methods in giving a picture of the malfunction frequency for the equipment categories and the extent to which site personnel are self sufficient in making repairs.

In order to compare the three methods in terms of the reported frequency of malfunction, each equipment category was ranked within each of the three methods according to the total number of malfunctions reported. The agreement among the ranks was determined by means of Kendall's W,[1] the coefficient of concordance. W was found to be .80 ($.01 > P > .001$). This coefficient is high enough to indicate a significant degree of comparability between the results of the three methods. In order to arrive at an over-all ranking of the malfunction frequency for the equipment areas, the ranks for each equipment category obtained by the three methods were averaged. On the basis of the averages, the ranking of the equipment categories from highest to lowest in terms of reported frequency of malfunction is as presented in Table 8.

Each data collection method was also compared with each of the others by intercorrelating the ranks obtained from each method. This analysis indicated that the correspondence between estimates of common malfunctions and records of actual malfunctions contained in the MR

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[1] As described in Siegel, S., Nonparametric statistics for the behavioral sciences. New York, McGraw-Hill, 1956.

Table 8

Ranking of Equipment Categories According to Malfunction Frequency

Rank	Equipment
1	Launcher-Loader Assembly
2	Missile RF and Electrical System and Test Responder
3	Launcher and Section Control Consoles
4	Missile Oil System
5	Miscellaneous Missile Parts
6	Missile Air System
7	Test Equipment
8	Miscellaneous LCT Equipment
9	Assembly and Servicing Equipment
10	Missile Propulsion System
11	Missile Warhead System

is quite high. This suggests that the estimate of common malfunctions is a realistic one. The estimate of common malfunctions (LAMJS) and the actual record of malfunctions (MR reports) show somewhat lower, but nonetheless significant, relationships with the malfunction frequencies reported on the SOD Ports. Since only quite disabling malfunctions are reported in the SOD Ports this is not an unusual finding.

The three malfunction data collecting devices, in somewhat different ways, give a picture of the degree to which site personnel are self sufficient in terms of dealing with malfunctions. It was estimated that site personnel correct 63% of their common malfunctions and 53.5% of the malfunctions reported as repaired on the MR. Although specific data are not available as to who repaired the malfunctions reported on the SOD Ports, it may be assumed that a high percentage of these malfunctions were beyond the repair capabilities of site personnel. This assumption is based on the belief that site personnel would make every effort to maintain a state of operational readiness and that they would, therefore, have promptly repaired the malfunctions reported on the SOD Ports if these repairs were within their capabilities.

A further estimate of site sufficiency is provided by the TABS (Trouble Analysis Behavior Survey) data. It was estimated by Launching Area personnel that they would repair 68% of the malfunctions causing the 583 malfunction indications developed for the TABS. When battery personnel were asked to specify the corrective action appropriate for each of the malfunction indications, the results were as follows. For 340 (58%) of the indications, a few steps leading directly to the malfunctioning part were specified. For 147 (25%) of the indications, only more general trouble shooting steps could be specified. For 96 (17%) it was immediately apparent to battery personnel that Ordnance assistance would be required.

DISCUSSION

The two salient features of this study are: (1) the provision of data descriptive of the maintenance requirements imposed by the equipment in the NIKE AJAX Launching Area and descriptive of the way in which these maintenance requirements are met, and (2) the provision of data suggestive of alternative ways in which these and other maintenance requirements can be met. The implications of these two research products will be discussed below.

Maintenance Requirements as Currently Met

The study has produced a reasonably detailed breakdown of those activities required to establish and maintain the operational readiness of the NIKE AJAX missile. In conjunction with the data showing which of the several MOS's assigned some maintenance responsibility typically perform the various maintenance tasks, these data can be helpful in evaluating and improving training given to these MOS's.

The evaluation of current training can be assisted by using these data as the basis for determining job-based training objectives for courses giving training to these MOS's. Comparison of some of these data with current course content, as well as comparison of course content with objectives, should be helpful.

Performance tests for use during and at the completion of training can be developed from these data.

Alternative Ways for Meeting Maintenance Requirements

Throughout this study there are data which suggest that maintenance requirements might be met more effectively if practices (in effect at the time of the study) were changed. The areas in which these changes could take place are:

(1) Preventive maintenance procedures.

(2) Job and training aids for maintenance technicians.

(3) Allocation of maintenance responsibility within the battery.

(4) Allocation of maintenance responsibility between the battery and Ordnance.

(5) Supervisory training for Missile Warrant Officers and Platoon Leaders.

1. Preventive Maintenance Procedures

Changes in this area are suggested especially by the finding involving the monthly missile RF check. It was found that missile current was reported to be out-of-tolerance on 67 (35%) of the 191 monthly check sheets studied. Further, it was found that this malfunction was never reported as a consequence of weekly checks. Failure to discover such a capability degrading malfunction, except on the monthly basis, can lead to a false sense of well-being on the part of Air Defense commanders. In addition to this specific finding, conversation between researchers and personnel who perform many of the daily and weekly checks indicated that some of these personnel did not consider certain check items important because they were not aware of the implications of malfunctions that could be uncovered by the checks. Researchers also gained the impression that little was done in the way of evaluating the conduct of checks on-site once check sheets were completed.

Several approaches to this problem are:

(1) Give more training in the conduct of checks to launcher area personnel (MOS 171).

(2) Assign more checks to the 223 and 172.

(3) Utilize completed check sheets as tools for more frequent inspections.

This study, however, does not provide sufficient data for a specific recommendation. Certainly, the understaffing at the time this study was conducted should be considered here.

2. Job and Training Aids for Maintenance Technicians

Inspection of manuals and schematics available to technicians on-site revealed that they did not provide the technician with nearly as much support as such materials could provide. In many cases schematics were hard to read because of inadequate layout and, in the case of schematics of the control consoles, were extremely hard to trace. Neither did manuals provide much in the way of continuity between check procedures and trouble analysis procedures. In spite of these deficiencies, however, maintenance technicians could specify fairly easily the corrective actions they would take for each of the 583 malfunction indications appearing on the TABS. Although, in some cases detailed steps could not be specified (and no attempt was made to validate these diagnostic efforts), these two classes of data (poor job aids and presumed ability to diagnose malfunctions fairly easily) suggest that job aids could be developed that would fairly quickly lead inexperienced technicians to malfunctioning components. The job aids envisioned here would include carefully laid out schematics and block diagrams and would make maximum use of symptom information provided by the equipment by specifying in detail the checks that should be made for each malfunction indication. Further research in this area is presently being carried out in HumRRO Subtask MAINTRAIN V.

3. Allocation of Maintenance Responsibility Within the Battery

Of considerable interest is the versatility of MOS 223. Except for a few periodic checks performed in the launcher area and trouble shooting the oil, air, and propulsion systems of the missile, this MOS has performed almost all organizational maintenance tasks associated with the NIKE AJAX missile. It seems clear that this MOS could, with little additional cross-training, assume the primary responsibility for all on-site maintenance. Also, it is clear that many of the maintenance tasks are reasonably simple in nature and that non-school trained MOS's can be trained on-site to handle them.

In terms of an optimum allocation of maintenance responsibilities, however, the data do not present a clear picture. The effect of the understaffing apparent in this study would have to be clarified, for example. These data do suggest, however, that some study might profitably be devoted to the problem.

4. Allocation of Maintenance Responsibility Between the Battery and the Ordnance

It is unrealistic to expect the Launching Area personnel to be 100% self sufficient in maintenance in view of their lack of specialized repair equipment and parts. However, some attention might be given to increasing their self sufficiency particularly when the present sample shows that they estimate that they are dependent on outside assistance for 37% of their estimated common malfunctions and for 46.5% of their actual malfunctions. Particular consideration might be given to the training, equipment, and logistic factors which tend to decrease their reliance on outside organizations.

Another rationale for reconsidering the 2nd and higher echelon maintenance split with respect to the NIKE AJAX missile is that the capability of battery level technicians is probably significantly greater than it was at the beginning of the NIKE AJAX program. Not only is it reasonable to assume that training has improved, but the backlog of experience built up within on-site units has probably had its effect also. Further, it is not uncommon for site personnel to perform higher echelon maintenance under the informal and unofficial auspices of supporting Ordnance units.

5. Supervisory Training for Missile Warrant Officers and Platoon Leaders

Data from this study reflect little actual maintenance work on the part of Missile Warrant Officers. During missile assembly and servicing activities, the only subtask which they typically performed was that of making entries in the logbook. They made very few of the prescribed preventive maintenance checks. They diagnosed only 6 and repaired only 3 of the 196 malfunctions reported on the Malfunction Record. They do, however, have an extensive supervisory role, but receive training no different from that which is given to 223's and 172's. The discrepancy discussed earlier regarding the weekly and monthly missile checks may be due to lack of supervisory training for the Missile Warrant. In view of the key position occupied by the Missile Warrant -- and the Launching Area Platoon Leader also -- it is believed that research in the area of training for technical supervision would be profitable. Research relevant to this problem is now being conducted in HumRRO Subtask SAMOFF IV.

APPENDIX A

PREVENTIVE MAINTENANCE CHECK FINDINGS

All specific check items required to complete a particular checking procedure have not been listed. Only those specific check items which led to the discovery of malfunctions have been listed.

1. <u>Daily Missile Maintenance Check</u>

Check Items	Malfunctions
(1) Oil leaks	34
(2) Air arming lanyard tightness	15
(3) Safety wire air arming lanyard	13
(4) Nose stagnation part plug flag	11
(5) Forward missile yoke pin flag	8
(6) Safety wire hydraulic ground power plug	7
(7) Hydraulic ground power plug proper connection	5
(8) Air leaks	5
(9) Sniff test	4
(10) Battery charging time	3
(11) Booster squib lead flag	2
(12) Air regulator pin flag	1
(13) Nose tip clean and open	1
(14) Low air pressure	1
(15) Corrosion	1
(16) Acid leaks	1
(17) Dents	1
	113

This malfunction count is based on 2,438 daily checks made on 21 different missiles with the number of checks per missile ranging from 48 to 170.

2. Weekly Missile Maintenance Check

Check Item	Malfunctions
(1) Lock on by MTR	54
	54

This malfunction count is based on a total of 1499 checks made on 79 different missiles with the number of checks per missile ranging from 5 to 43.

3. Monthly Missile RF Check

Check Item	Malfunctions
(1) Missile current	67
(2) Missile voltage	25
(3) Response time	10
(4) -5g Pitch	2
(5) 0g Yaw	2
(6) Fin input - pitch	2
(7) Accelerometer inputs	1
(8) Gyro slew - preset	1
(9) Fin input - roll	1
	111

This malfunction count is based on 182 checks made on 25 different missiles with the number of checks per missile ranging from 1 to 12.

4. <u>Fuel and Servicer Maintenance Check</u>

Check Items	Malfunctions
(1) General appearance - no rust, dirt, excess oil	2
(2) Winch and brake - operate freely	2
	4

This malfunction count is based on a total of 124 checks made on 6 different equipments with the number of checks per equipment ranging from 8 to 38.

5. <u>Weekly Booster Dolly Maintenance Check</u>

A total of 134 checks was made on 10 different dollies with the number of checks per dolly ranging from 8 to 38. No malfunctions were reported.

6. <u>Weekly Missile Hoist Beam Maintenance Check</u>

Check Items	Malfunctions
(1) Pin assemblies - intact, pins and chains secure	1
(2) Overall paint appearance - no rust or bare spots	1
	2

This malfunction count is based on a total of 29 weekly checks made on 2 different beams with the number of checks per beam ranging from 13 to 16.

7. Weekly Booster Hoist Beam Maintenance Check

Check Item	Malfunction
(1) Pin assemblies - pins and chains secure	3
	3

This malfunction count is based on a total of 70 checks made on 4 different beams with the number of checks per beam ranging from 8 to 39.

8. Weekly Guidance Section Dolly Maintenance Check

A total of 62 checks was made on 3 different dollies with the number of checks per dolly ranging from 9 to 39. No malfunctions were reported.

9. Weekly Booster Joining Hoist Maintenance Check

Check Item	Malfunction
(1) A frame - not bent, cracked or broken welds	1
	1

This malfunction count is based on a total of 54 checks made on 2 different hoists with the number of checks per hoist ranging from 15 to 39.

10. Weekly Launcher-Loader Maintenance Check

Check Items	Malfunctions
(1) Launcher operating panel - not damaged, operates, all switch covers intact	21
(2) Speaker system - works	9
(3) Missile testing hydraulic unit - doors, valves, gauges, operation, no leaks	5
(4) Erection hydraulic unit - ddors, valves, gauges, operation, no leaks	3
(5) Lube fittings (6) - properly marked, clean	2
(6) Erecting piston - clean, moves freely, locks up	2
(7) Junction box - not damaged, operates	2
	44

This malfunction count is based on a total of 574 checks made on 31 different loaders with the number of checks per loader ranging from 4 to 48.

11. Weekly Launching and Transporter Rail Maintenance Check

Check Items	Malfunction
(1) Outrigger wheels - intact, lubricated	8
(2) Lube fittings (10)	5
(3) Launcher rail jack - operates freely, bearing screw greased	1
	14

This malfunction count is based on a total of 2,324 checks made on 96 different rails with the number of checks per rail ranging from 1 to 65.

12. Weekly Universal Handling Dolly Maintenance Check

A total of 59 checks was made on 2 different dollies with the number of checks per dolly listed as 20 and 39. No malfunctions were reported.

13. Weekly Missile Dolly Maintenance Check

Check Item	Malfunction
(1) Swivel casters - index locks, wheels operate freely	2
	2

This malfunction count is based on a total of 314 checks made on 10 different dollies with the number of checks per dolly ranging from 15 to 52.

14. Weekly Missile Handling Ring Maintenance Check

A total of 13 checks was made on one ring. No malfunctions were reported.

15. Weekly Missile RF Test Set

Check Items	Malfunction
(1) Interior - all plugs, tubes, connectors tight, check for signs of corrosion or overheating of components, no dust, lint	8
(2) Air filters - clean, no obstruction in vents	5
(3) Components - clean	3
(4) Connectors - shell, connectors, pins, intact	2

(5)	Saddle - antenna couplers, connectors intact, wave guide coupler, attenuators operate	2
(6)	Calibrate - all components work	1
(7)	Cables - check for wear, damage	1
		22

This malfunction count is based on a total of 131 checks made on 6 different sets with the number of checks per set ranging from 8 to 52.

16. <u>Weekly Propulsion Plumbing Tester Maintenance Check</u>

A total of 42 checks was made on 2 different testers with the number of checks per tester ranging from 16 to 26. No malfunctions were reported.

17. <u>Weekly Hydraulic Test Stand Maintenance Check</u>

A total of 63 checks was made on 3 different stands with the number of checks ranging from 8 to 39. No malfunctions were reported.

18. <u>Weekly Transporter Trailer Maintenance Check</u>

Check Items	Malfunctions
(1) Drawbar - not bent or broken	3
(2) Safety chains	1
(3) Bad leveling system - no leaking, operation O.K.	1
(4) Pump handle and chain	1
(5) Electrical system, brakes and lights	1

(6)	Reflectors	1
(7)	Accessories	1
		9

This malfunction count is based on a total of 36 checks made on 1 trailer.

19 Weekly Missile Booster Storage Rack Maintenance Check

Check Items		Malfunction
(1)	Truss frames - no rust, cracks, bent members	16
(2)	Attach pins - chains fastened, pins lubricated	1
(3)	Overall appearance of paint - no rust or bare spots, clean	1
(4)	Locks and hinge pins - no rust, properly lubricated	1
		19

This malfunction count is based on a total of 37 checks made on 2 different racks with the number of checks per rack ranging from 11 to 26.

20. Weekly Warhead Handling Yoke Maintenance Check

Check Items		Malfunction
(1)	Pins - no damage, wear, crack or breaks	2
(2)	Rings - no damage, wear, cracks, or breaks	1
		3

This malfunction count is based on a total of 91 checks made on 2 different yokes with the number of checks per yoke ranging from 52 to 39.

21. Weekly Section Control Console Maintenance Check

Check Item	Malfunction
(1) Control panel lights and switches	9
(2) Spare fuses present	5
(3) Power cabinet switches	3
(4) Power cabinet blower	3
(5) Control panel fuses - tight, correct size	2
	22

This malfunction count is based on a total of 17 checks made on 4 different consoles with the number of checks per console ranging from 1 to 8.