AN INVESTIGATION OF THE RELATIONSHIPS BETWEEN AUXILIARY EQUIPMENT READINE (U) NAVAL POSTGRADUATE SCHOOL MONTEREY CA C C WILLIS DEC 84
THESIS

AN INVESTIGATION OF THE RELATIONSHIPS BETWEEN AUXILIARY EQUIPMENT READINESS AND AUXILIARY MAINTENANCE PERSONNEL CHARACTERISTICS

by

Clarence C. Willis

December 1984

Thesis Co-advisors: Ronald A. Weitzman
Thomas G. Swenson

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An Investigation of the Relationship Between Auxiliary Equipment Readiness and Auxiliary Maintenance Personnel Characteristics

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An Investigation of the Relationships Between Auxiliary Equipment Readiness and Auxiliary Maintenance Personnel Characteristics

by

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Lieutenant Commander, United States Navy
B.S., United States Naval Academy, 1972

Submitted in partial fulfillment of the requirements for the degree of Master of Science in Management from the NAVAL POSTGRADUATE SCHOOL December 1984

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ABSTRACT

To evaluate the effectiveness of training similar to that associated with a proposed auxiliary equipment rating, the analysis reported here examined the relationship between auxiliary equipment readiness on eighteen FFG-7 class ships and the quality, experience, and training of the personnel assigned to the ships. More experience, higher numbers of trained personnel, and higher numbers of high school graduates were hypothesized to contribute to lower equipment downtime. Results of the analysis support this hypothesis in the case of quality and training. Increased experience, however, is found to be directly related to equipment downtime on the FFG-7 class ships. The amount of variation in total downtime attributable to personnel characteristics is small, however, when compared with that attributable to ship effects, as measured by average ship downtime. Accounting for ship effects in this study facilitated a meaningful analysis of the personnel-characteristics effects. The results of this analysis indicated that an increase in training coupled with improved selection and retention of relatively higher quality personnel would contribute to a reduction in downtime of auxiliary equipments on FFG-7 class ships.
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I. INTRODUCTION

A. RESOURCES AND READINESS

In recent years, the U. S. Navy has been under increasing pressure to justify expenditures for proposed resources by demonstrating their impact upon military readiness. Demonstration of the link of resources to readiness is difficult. The elusive entity called readiness ultimately refers to the ability of the Navy to perform assigned wartime tasks. The measures which are used to assess readiness are, in fact, proxy measures of the organization's ability to fight and win at war. Since fighting wars merely to assess the ability of units to perform their wartime missions is impractical, the Navy uses readiness reports from operational commanders and exercise or inspection reports to assess its readiness [Ref. 1].

Personnel resources needed to achieve readiness are both expensive and difficult to manage. Placing the right person from the Navy's half million personnel in the right position with the appropriate skills at the proper time makes the manpower manager's task challenging.

The relationships between personnel policy implementation and readiness are complex and often confusing. In some cases, the high quality of the personnel assigned may offset the impact of insufficient numbers of personnel. Depending upon the nature of the tasks personnel are required to perform, the opposite case, substituting quantity for quality, may adversely affect readiness. Better decisions concerning resource allocation can be made if the costs and effects on readiness of changes in personnel quality and quantity are known. Then, comparison with the costs and
effect on readiness of other resource expenditures such as new systems acquisitions or operating funds can be made intelligently. The purpose of this thesis is to analyze the effect of auxiliary equipment maintenance training upon auxiliary equipment readiness as measured by CASREP downtime.

B. AUXILIARY EQUIPMENT

As the Navy's ships and systems become more complex, they grow more dependent upon auxiliary equipments. "Auxiliary equipments are defined as any shipboard machinery, equipments or systems under the cognizance of the ship's engineer officer which are not directly involved in the operations of the ship's main propulsion system(s)" [Ref. 2]. A listing of typical surface shipboard auxiliary equipments is presented in figure 1.1. Many, if not all, of these equipments have a functional relationship to a ship's operational capability. Essential electronics systems such as radars, weapons systems and communication equipments depend upon auxiliary equipments for cooling and dry air essential to their operation. Inoperability of the aircraft or weapons elevators on aircraft carriers can incapacitate the Navy's most costly aircraft. Failure of cargo systems on underway replenishment ships can result in their inability to perform their primary mission. Steering gear, one of the most common auxiliary equipments, is critical for the accomplishment of every ship's mission. The diversity of auxiliary equipments is one source of the problems associated with them. As can be seen from figure 1.1, they are combinations of hydraulic, pneumatic, electrical, electronic, steam, mechanical and cryogenic systems.

The increasing importance of auxiliary equipment to accomplishment of the Navy's missions coincides with a trend
Figure 1.1  Typical Surface Ship Auxiliary Equipments

toward increased complexity in auxiliary equipments as modern technologies are incorporated into auxiliary systems. For example, in the past the control mechanism for auxiliary equipment may have been a simple fly-weight governor or a manually operated on-off switch. Today these same functions are performed by electro-hydraulic governors and solid state controls. The continuing trends toward reduced manning and increased automation lead to the conclusion that auxiliary systems will grow more complex in the future.
C. AUXILIARY SPECIALIST RATING PROPOSAL

In 1975 Commander Naval Sea Systems Command (NAVSEA) proposed that a rating, Marine Auxiliariesman (MX), be formed specifically to perform organizational and intermediate level maintenance on auxiliary equipments. At that time, the proposed rating applied to both surface ships and submarines. Then, as today, the Machinist Mate (MM) and Engineman (EN) ratings performed the majority of auxiliary equipment maintenance with support from the Electrician Mate (EM) and Interior Communications (IC) ratings. The reasons listed as justification for the new rating were:

1. identification of personnel with auxiliary maintenance skills by Navy Enlisted Classification Codes (NEC's) only, allowed so much latitude in their assignment that experienced auxiliary maintenance personnel frequently served in areas other than auxiliary maintenance;

2. little reinforcement of auxiliary maintenance skills was achieved in the rating examinations of the source ratings for auxiliary maintainers, EN and MM; and

3. failure to employ skilled auxiliary maintenance technicians in that capacity resulted in attrition of skills which would not occur if they were in a separate rating, consistently employed in auxiliary maintenance.

The rating proposal called for the new MX rating to be formed from the EN and MM ratings.

For a variety of reasons, the auxiliary rating was not approved in 1976. Specific concerns were: the proposed rating's reduction in the commanding officer's latitude in the assignment of personnel within his ship; uncertainty over how many personnel would be required in the new rating; uncertainty about the effect of the recently formed Gas
don't. Figure 3.2 displays the amount of downtime subdivided into categories, awaiting parts and not awaiting parts, as well as, the percentage of downtime for each major equipment category.

No attempt was made to account for the different severity levels of CASREPS in this analysis since most of the CASREPS were of the same level, C-2 (marginal degradation of mission). It is difficult to describe, in an academically acceptable way, the intense pressure on ships.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>WEITZ</td>
<td>A control variable equal to the mean auxiliary equipment downtime per each ship (measured in days).</td>
</tr>
<tr>
<td>NRAUXTEX</td>
<td>The number of Enginemen onboard a ship in a specific quarter with auxiliary equipment training (NEC 4381 or 4382).</td>
</tr>
<tr>
<td>NRACTEX</td>
<td>The number of Enginemen onboard a ship during a specific quarter with air conditioning training NEC 4294.</td>
</tr>
<tr>
<td>NRNONNEC</td>
<td>The number of Enginemen onboard a ship in a specific quarter who had no NEC assigned.</td>
</tr>
<tr>
<td>NRHSSGRAD</td>
<td>The number of Enginemen onboard a ship during a specific quarter who had completed high school.</td>
</tr>
<tr>
<td>QTRSEXP</td>
<td>Total quarters of experience onboard; the sum of the quarters onboard of all of the Enginemen assigned to a ship during a specific quarter.</td>
</tr>
</tbody>
</table>

Figure 3.3 Control and Independent Variables
Figure 3.2  Categories of Downtime

considered responsive to the quantity and quality of the maintenance personnel assigned to the ship. The ship that submits correct work requests and frequently checks the status of its jobs under repair by outside activities inevitably receives faster, better repair work than ships which
Variable Definition

DWNTOT— the total auxiliary equipment downtime reported by a ship in a quarter measured in days.

DWNSUP— the total time in days the ship was awaiting parts as reported by the Casualty Report. In cases where parts were ordered but no awaiting parts figure was reported by the ship, DWNSUP was estimated based on requisition submission and receipt dates.

DWNOTHER— the difference between total downtime and downtime awaiting parts.

Figure 3.1 Dependent Variables

Previous studies have concentrated on the portion of total downtime not awaiting parts as the primary criterion against which maintenance effectiveness should be measured [Ref. 15].

The conceptual framework used in this study is similar to that of a fleet operational commander. The analysis assumes that total downtime is the best criterion to use in adjudging the performance of maintenance personnel. Total downtime is the figure most readily available to operational commanders in assessing ship's equipment readiness. Also, the portion of downtime spent awaiting parts can be reduced by submission of correct requisitions, and aggressive follow-up of supply requisitions. Thus the supply system is really another tool which the technician must be able to use to effect repair to the casualty. Repairs accomplished above the shipboard level (i.e., Depot level, Tender, and Intermediate Maintenance Activity) are also
number of days downtime awaiting parts and the number of

days downtime not awaiting parts for each casualty in each
of the 19 quarters under analysis. The number of days for
each category of downtime (total, awaiting parts, and not
awaiting parts) is apportioned to the quarters in which they
occurred.

3. Sample

The personnel and CASREP data bases were merged,
muching the data by ship and quarter. The resulting data
base contained 213 observations. Each observation contained
both personnel and CASREP information on a ship during one
of the nineteen quarters in the analysis. As shown in
figure 2.1 not all ships under analysis here were in commis-
sion for the full period of the analysis. Appendix F
contains a detailed description of the raw data and the
final data base used in this analysis which was formed using
the programs in Appendices B through D. Both the raw data
and the data used in this analysis are stored on magnetic
tape at the Naval Postgraduate School.

B. ANALYSIS

1. Dependent Variables

For this study, total downtime measured in days and
its subcomponents downtime awaiting parts and downtime not
awaiting parts were used as the dependent variables in
regression analysis. These variables and their definitions
are listed in figure 3.1.
were subsequently promoted to engineman fireman (ENFN) or above on one of the included ships during the period of the analysis. Each of the records contained the following information: (1) Armed Forces Qualifying Test (AFQT) score, (2) high school degree status, (3) current age in years, (4) years of active duty service, (5) the time onboard the ship in quarters, and (6) the individual's assigned Navy Enlisted Classification Code (NEC), if any.

Next, aggregation of the data for each ship and each quarter was accomplished. The program provided the following information for each ship in each quarter: 1) number of enginemen who were high school graduates, 2) number of enginemen onboard each ship in a quarter who held NEC 4381 or 4382 indicating auxiliary training, 3) number of enginemen onboard each ship in a quarter who held NEC 4294 indicating air conditioning training, 4) number of enginemen onboard each ship in a quarter who held no NEC, 5) the sum of the time onboard for all of the enginemen onboard a ship in a quarter, and 6) the mean AFQT score of the enginemen onboard a ship in a quarter.

2. CASREP Data

The CASREP data base was formed by selecting those Equipment Identification Codes (EIC) associated with the Enginemen rating onboard the FFG 7 class. This data base contained the date the casualty was reported, the date the casualty was corrected, the number of hours the ship reported the repair was delayed while awaiting parts, the name and EIC of the equipment, the maintenance level at which the repair was accomplished and the severity level of the CASREP. These data were processed using the programs in Appendix C to produce a file containing information on the casualties reported by each ship during each quarter. The program computes the number of days of CASREP downtime, the
III. METHODOLOGY

A. DATA

Two data bases were used in this analysis. Defense Manpower Data Center (DMDC), Monterey, California, provided information concerning the Enginemen serving onboard the selected FFG 7 class ships during the period of interest. A second data base containing information on auxiliary equipment casualty reports (CASREPS) was provided by American Management Incorporated of Washington, D.C.

1. Personnel Data

The personnel data were obtained from the DMDC Enlisted Cohort File. The Cohort File contains personnel information on each enlisted man in the Navy and is updated each quarter. Using the time period of the analysis and the Unit Identification Codes (UIC) of the ships in Figure 2.1, the Enginemen who had served on any of the ships during any quarter of interest were selected. Using the programs in Appendix B, these records were processed to generate an observation on each individual for each quarter he was aboard one of the ships in the study. Since the DMDC records contain no reporting-aboard date, this analysis assumes that an individual who was listed onboard a unit at the end of a quarter was onboard for the entire quarter. Enginemen of all paygrades were selected, from designated firemen through master chief petty officer. Non-designated firemen were not included in this analysis since no information exists within the DMDC files that can be used to associate them with the auxiliary division. Thus, the only non-designated firemen included in the study are those who
Basic EngineMan CIN A-652-0019
This course provides trainees with training in the systems and associated components required for Engineman "C" school including principles of diesel engines and related equipments.

FFG7 Introduction to Engineering Systems Maintenance Management A-652-0152
This course provides training to engineering personnel assigned to FFG7 class ships with the skills to understand and monitor the operation of the engineering systems. Training on systems parameters of the main engines, high and low pressure air compressors, fuel oil, ballasting electrical distribution, firepumps and firemain system.

FFG7 Auxiliary Mechanical Subsystems Maintenance CIN A-652-0158
This course provides training in the operation and maintenance of high and low pressure air compressor systems, electronic cooling water systems and the incinerator including intermediate level maintenance.

Basis Hydraulics for FFG7 Auxiliaries CIN A-652-0164
This course provides knowledge and skills for Engineman paygrades E-1 to E-5 to maintain hydraulic systems and components. The course covers hydraulic principles, hydraulic piping, tubing, hoses, fluids and seals, hydraulic reservoirs, strainers, filters, hydraulic pumps, valves, basic system component's symbols on schematics.

Detroit Diesel Allison 16 V149TI5h Service Diesel Generator A-652-0166
This course provides training in the operation and maintenance and repair of the Detroit Diesel 149TI series engines including disassembly, assembly, functional adjustments, and troubleshooting an operational engine under load.

FFG-7 Class Waste Heat System Maintenance CIN A-652-0167
This course provides training in the operation, maintenance and repair of FFG-7 class waste heat system, including details of construction, functional adjustments and control of abnormal operating conditions.

FFG-7 Class Mechanical Systems Technician CIN A-652-0159 (NEC 4382 only)
This course teaches organizational level maintenance on the mechanical components of the oily water separator, pallet elevator, and auxiliary propulsion system on the FFG-7 class ships.

Source: Service School Command Great Lakes NCA Self Study Report

Figure 2.3 Training courses for Engineman NEC's 4381 and 4382
FFG7 auxiliary maintenance course is similar in length and content to the proposed pipeline included in NAVSEA's 1976 rating proposal. Additionally, sailors completing the course are awarded Navy Enlisted Classification (NEC) codes which identify them in manpower data records.

C. FFG 7 AUXILIARY TRAINING

The auxiliary maintenance courses being tested for association with auxiliary equipment downtime are taught at Service School Command, Great Lakes, Illinois. The courses are FFG 7 Auxiliary Mechanical Sub-systems Technician Class (Course Identification Number A-652-0233) which results in attainment of NEC 4381; and FFG7 Auxiliary Mechanical Systems Technician (Course Identification Number A-652-0235) which results in attainment of NEC 4382 [Ref. 12] [Ref. 5]. The courses are both training pipelines for the Engineman rating consisting of modules which are described in detail in figure 2.3. The modules provide training in valve maintenance, diesel engine maintenance, hydraulic systems, and air compressor systems, as well as some training in electricity and electronics. The training is specifically tailored to the FFG-7 class ships with operating equipments available for training on many of the systems onboard those ships.

Initially the FFG-7 auxiliary maintenance course was strictly a classroom course with almost no hands-on training. Since November of 1979, when the first equipments for hands-on training were installed, the course has included more and more hands on training [Ref. 14]. Thus, it must be kept in mind that the training examined here has changed over the period in the analysis.
<table>
<thead>
<tr>
<th>RATE</th>
<th>PRIMARY NEC</th>
</tr>
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<tbody>
<tr>
<td>ENC</td>
<td>none</td>
</tr>
<tr>
<td>EN1</td>
<td>4382</td>
</tr>
<tr>
<td>EN1</td>
<td>4294*</td>
</tr>
<tr>
<td>EN2</td>
<td>4381</td>
</tr>
<tr>
<td>EN2</td>
<td>4381</td>
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<tr>
<td>EN3</td>
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<tr>
<td>EN3</td>
<td>4381</td>
</tr>
<tr>
<td>EN3</td>
<td>4294</td>
</tr>
<tr>
<td>EN3</td>
<td>none*</td>
</tr>
<tr>
<td>ENFN</td>
<td>none*</td>
</tr>
<tr>
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<td>FN</td>
<td>9760*</td>
</tr>
<tr>
<td>FN</td>
<td>9760</td>
</tr>
</tbody>
</table>

* indicates billet is designated as Selected Reserve billet on FFG's in the Naval Reserve Force.

Source: OPNAVINST 5320.427A SHIP MANNING DOCUMENT FOR FFG 7

Figure 2.2 SMD Manpower Requirements for the Engineman Rating on the FFG-7 class

The Ship Manning Document (SMD) for the FFG 7 class establishes the requirement for 11 enginemen and 2 nondesignated firemen in the auxiliary division. The SMD also establishes the requirement that 5 of the 11 enginemen hold either the 4382 or 4381 NEC; 2 of the 11 enginemen should hold NEC 4294 (air conditioning and refrigeration) [Ref. 10].

The manning concept of the class--reduced manning--places a premium on the ability of each sailor [Ref. 11]. If training is related to the operability of the ship equipments, perhaps this manning concept will accentuate it. The
<table>
<thead>
<tr>
<th>SHIP HULL NO.</th>
<th>NAME</th>
<th>COMMISSIONING DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>FFG07</td>
<td>OLIVER HAZARD PERRY</td>
<td>DEC77</td>
</tr>
<tr>
<td>FFG08</td>
<td>MCINERNEY</td>
<td>NOV79</td>
</tr>
<tr>
<td>FFG09</td>
<td>WADSWORTH</td>
<td>FEB80</td>
</tr>
<tr>
<td>FFG10</td>
<td>DUNCAN</td>
<td>MAY80</td>
</tr>
<tr>
<td>FFG11</td>
<td>CLARK</td>
<td>MAY80</td>
</tr>
<tr>
<td>FFG12</td>
<td>GEORGE PHILIP</td>
<td>OCT80</td>
</tr>
<tr>
<td>FFG13</td>
<td>SAMUEL ELIOT MORRISON</td>
<td>OCT80</td>
</tr>
<tr>
<td>FFG14</td>
<td>JOHN H. SIDES</td>
<td>MAY81</td>
</tr>
<tr>
<td>FFG15</td>
<td>ESTOCIN</td>
<td>JAN81</td>
</tr>
<tr>
<td>FFG16</td>
<td>CLIFTON SPRAGUE</td>
<td>MAR81</td>
</tr>
<tr>
<td>FFG19</td>
<td>JOHN A. MOORE</td>
<td>NOV81</td>
</tr>
<tr>
<td>FFG20</td>
<td>ANTRIM</td>
<td>SEP81</td>
</tr>
<tr>
<td>FFG21</td>
<td>FLATLEY</td>
<td>JUN81</td>
</tr>
<tr>
<td>FFG22</td>
<td>FAHRION</td>
<td>JAN82</td>
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<tr>
<td>FFG23</td>
<td>LEWIS B. PULLER</td>
<td>APR82</td>
</tr>
<tr>
<td>FFG24</td>
<td>JACK WILLIAMS</td>
<td>SEP81</td>
</tr>
<tr>
<td>FFG25</td>
<td>COPELAND</td>
<td>AUG82</td>
</tr>
<tr>
<td>FFG26</td>
<td>GALLERY</td>
<td>DEC81</td>
</tr>
</tbody>
</table>

(Source: Jane's Fighting Ships 1984-85)

Figure 2.1 Ships covered in Analysis

The manpower requirements for the FFG-7 class from the Ship Manpower Document (SMD) for the Engineman rating are shown in Figure 2.2.
"...a higher EN paygrade structure is associated with improved readiness aboard the Spruance Class destroyers (fewer total CASREPS, fewer level-3 CASREPS, improved SPCC Readiness Index and fewer supply downtime hours...." [Ref. 7].

In their conclusions, the same authors state "a cursory review of (our study) does not provide any consistent support for the idea that an older, more experienced, better educated, smarter, more senior, less turbulent, more fully-staffed Navy is a uniformly good idea...." "...simple main effects that may accrue to such ideas are deeply buried in a morass of rating--by--ship class--by attribute interactions" [Ref. 8].

B. FFG 7 AUXILIARY MANNING

The training of the auxiliary maintainers on the FFG 7 class is similar to that proposed for the auxiliary equipment rating. This similarity makes the FFG 7 class well suited for an analysis of the effect of auxiliary equipment training upon auxiliary equipment readiness. The FFG 7 class ships in Figure 2.1 are included in the analysis reported here. The analysis covers the auxiliary maintenance personnel and auxiliary equipment readiness of those ships for 19 quarters, October 1979 through June 1984.

Relatively new, the FFG 7 class has not been extensively analyzed. The lead ship in the class was commissioned in late 1977 and follow on ships were lagged two years behind the lead ship to allow implementation of lessons learned. The ships listed in fig 2.1 had enough operational experience to have a CASREP history. The class has 35 ships in commission already with 16 additional ships scheduled for completion by 1987 [Ref. 9].
II. DISCUSSION AND LITERATURE REVIEW

A. LITERATURE REVIEW

Prior attempts to demonstrate the relationship between readiness and personnel characteristics have produced mixed and often counter-intuitive results. In fact, the results of the prior work lead to the conclusions that even the Navy's "sacred cows"—retention and experience—are not universally good and appropriate to all situations. For example, the personnel who are retained may be merely adequate performers who self select because they are unemployable in the civilian labor market. In that case the Navy may be quietly undermining its senior enlisted leadership five to ten years in the future, while maintaining a laudatory retention rate.

If you ask any Fleet Naval Officer how much off ship training is needed for his sailors or how many sailors he needs, chances are the answer will usually be "MORE!" The manpower research in this area doesn't always support the default answer. In one of the earliest studies in this area, Horowitz and Sherman document a training effect on casualty report (CASREP) downtime only in ratings which maintain complex systems such as Fire Control Technician (FT). In the ratings most similar to the proposed auxiliary maintenance technicians, Machinist Mates (MM) and Boiler Technician (BT), Horowitz and Sherman found that decreases in equipment downtime were associated with increasing total numbers of men, but not their training [Ref. 6]. In a later study of several ratings and classes, McGarvey, Elster and May found:
maintenance technician rating [Ref. 5]. From these NEC's, those serving on the FFG 7 class were selected for analysis of the auxiliary training.

<table>
<thead>
<tr>
<th>Rating/NEC</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MM-4283</td>
<td>High and Low Pressure Cryogenic Technician</td>
</tr>
<tr>
<td>MM-4291</td>
<td>Centrifugal Air Conditioning Mechanic</td>
</tr>
<tr>
<td>MM-4294</td>
<td>Refrigeration and Air Conditioning Mechanic</td>
</tr>
<tr>
<td>MM-4295</td>
<td>Underway Replenishment Mechanic</td>
</tr>
<tr>
<td>MM-4296</td>
<td>Shipboard Elevator Hydraulic/Mechanical Systems Technician</td>
</tr>
<tr>
<td>MM-4221</td>
<td>IMA Outside Machine Shop Journeyman</td>
</tr>
<tr>
<td>EN-4381*</td>
<td>FFG-7 Class Auxiliaries Mechanical Subsystem Technician</td>
</tr>
<tr>
<td>EN-4382*</td>
<td>FFG-7 Class Auxiliaries System Technician</td>
</tr>
<tr>
<td>EN-4398</td>
<td>DD 963 Auxiliaries System Technician</td>
</tr>
<tr>
<td>EM-4668</td>
<td>Underway Replenishment Electrical Component Maintenance (Denison)</td>
</tr>
<tr>
<td>EM-4669</td>
<td>Underway Replenishment Electrical Component Maintenance (United)</td>
</tr>
<tr>
<td>EM-4671</td>
<td>Shipboard Elevator Electronic Electrical Systems Technician</td>
</tr>
</tbody>
</table>

*included in analysis

Figure 1.2 Surface Navy Enlisted Classifications (NEC) related to Auxiliary Equipment
Turbine rating on the auxiliary maintenance situation; and uncertainty about the effect of forming the proposed ratings from the source ratings EN and MM [Ref. 3]. As a result, the EN and MM ratings still perform the majority of the maintenance on auxiliary equipments even though they are trained primarily for main propulsion duties.

NAVSEA's proposal of a new rating in 1984 quite similar to that disapproved in 1976 points out that the auxiliary equipment maintenance problems are still of concern in some areas of the Navy. In April of 1984, six auxiliary systems were included in the eight equipments identified as having high failure rates by NAVSEA's Detection and Response Technique (DART) program [Ref. 4]. The proposal of an auxiliary equipment rating as a partial solution to auxiliary equipment maintenance problems presumes that a new rating will improve maintenance performance by providing technicians with better training and that improved technician performance will result in less downtime for auxiliary equipments. Also the proposed rating would allow better management of auxiliary equipment maintenance personnel, particularly in the areas of distribution to fill ship manning requirements and in the area of identification and utilization of personnel with auxiliary equipment training or experience.

A critical unknown is whether or not additional training of auxiliary equipment maintenance personnel has any effect upon auxiliary equipment readiness. How to answer this question is a problem, since the exact training the proposed rating would provide cannot be tested. The next best alternative is to examine similar training to see what relationships exist with auxiliary equipment operability.

The Navy Enlisted Classifications listed in figure 1.2 were examined to select those which were most similar in range of abilities and skills to the proposed auxiliary
to correct equipment casualties reported by CASREP. If an equipment is reported by CASREP, the maintenance personnel are (or should be) doing everything they can to repair the inoperative equipment. Thus, the severity level of the CASREP lends little clarification of the relationships under investigation.

2. Independent Variables

In order to determine the effect of training and other personnel characteristics upon auxiliary equipment downtime, it was necessary to account for additional factors that affect equipment downtime. Some of these factors, which differ from ship to ship, are equipment design, ship age, personnel morale and motivation, deployment and operating schedules, and the willingness of commanding officers to submit CASREPS. The variable used to account for the effects other than personnel characteristics is each ship's quarterly average auxiliary equipment downtime over the period of the analysis (variable WEITZ). This ship variable thus serves as a control variable.

The independent variables used in the analysis are defined in figure 3.3. In order to allow a more meaningful interpretation of the coefficients of regression for the independent variables, numerical values instead of fill ratios were used. This use allows the coefficient of the independent variable to be interpreted cautiously as the change in total downtime that would result from the addition of one man with the characteristic described by the independent variable. In the case of the experience measure in the model (variable QTRSEXP), the coefficient of regression may be interpreted as the change in downtime resulting from one engineman remaining onboard for 1 additional quarter. It must be kept in mind that interpretation of the coefficient of regression in this manner invokes the assumption that all other variables are held constant!
3. Method and Model

The basic model used for this analysis includes total CASREP downtime (variable DWNTOT) as the criterion against which the effects of the independent variables are measured. Other models using downtime awaiting parts (variable DWNSUP) and downtime not awaiting parts (variable DWNOTHER) as the dependent variables are examined briefly. The independent variables include static measures of the training, quality, and experience of the enginemen in the auxiliary maintenance division on the FFG-7 class ships. The measures of personnel training are the number of trained enginemen (variables NRAUXTEX and NRACTEX) and the number of untrained enginemen (variable NRNONNEC). The measure of personnel quality in the model is the number of enginemen who are high school graduates (variable NRHSGRAD). The measure of experience in the model is the total number of quarters the enginemen on a ship have spent on that ship (variable QTRSEXP). Simple descriptive statistics for all of the variables included in the analysis are shown in figure 3.4.

Intuitively acceptable results from this analysis would be an increase in downtime associated with increases in the control variable (variable WEITZ) and with increases in the number of untrained enginemen (variable NRNONNEC). We would expect a decrease in downtime to be associated with increased numbers of trained individuals onboard (variables NRAUXTEX and NRACTEX) and with increased experience (variable QTRSEXP).

Regression analysis was used to determine the linear-composite weights as well as the significance of the independent variables in their relationship to each dependent variable. Appendix E displays an example of the programs used to conduct the regression analysis. Both the
<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>N</th>
<th>MEAN</th>
<th>STD ERROR OF MEAN</th>
<th>MINIMUM VALUE</th>
<th>MAXIMUM VALUE</th>
<th>STANDARD DEVIATION</th>
<th>VARIANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>DWNTOT</td>
<td>213</td>
<td>130.16</td>
<td>8.23</td>
<td>1.00</td>
<td>696.00</td>
<td>120.11</td>
<td>14427.05</td>
</tr>
<tr>
<td>DWNSUP</td>
<td>213</td>
<td>73.56</td>
<td>5.72</td>
<td>0.00</td>
<td>506.90</td>
<td>85.43</td>
<td>7298.38</td>
</tr>
<tr>
<td>DWNOTHER</td>
<td>213</td>
<td>46.93</td>
<td>3.72</td>
<td>0.00</td>
<td>279.00</td>
<td>34.28</td>
<td>2946.39</td>
</tr>
</tbody>
</table>

**Dependent Variables**

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>N</th>
<th>MEAN</th>
<th>STD ERROR OF MEAN</th>
<th>MINIMUM VALUE</th>
<th>MAXIMUM VALUE</th>
<th>STANDARD DEVIATION</th>
<th>VARIANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>MNAFQT</td>
<td>213</td>
<td>45.09</td>
<td>0.70</td>
<td>0.00*</td>
<td>88.00</td>
<td>11.63</td>
<td>135.30</td>
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<tr>
<td>MNYRADS</td>
<td>213</td>
<td>6.54</td>
<td>0.11</td>
<td>3.29</td>
<td>20.00</td>
<td>1.89</td>
<td>3.59</td>
</tr>
<tr>
<td>NRACTEX</td>
<td>213</td>
<td>1.42</td>
<td>0.05</td>
<td>0.00</td>
<td>4.00</td>
<td>0.89</td>
<td>0.79</td>
</tr>
<tr>
<td>NRAUXTEX</td>
<td>213</td>
<td>2.05</td>
<td>0.11</td>
<td>0.00</td>
<td>7.00</td>
<td>1.89</td>
<td>3.58</td>
</tr>
<tr>
<td>NRSGRAD</td>
<td>213</td>
<td>7.10</td>
<td>0.15</td>
<td>0.00</td>
<td>13.00</td>
<td>2.44</td>
<td>5.93</td>
</tr>
<tr>
<td>NRRNONNCE</td>
<td>213</td>
<td>5.62</td>
<td>0.16</td>
<td>0.00</td>
<td>14.00</td>
<td>2.66</td>
<td>7.06</td>
</tr>
<tr>
<td>MNPAYCRD</td>
<td>213</td>
<td>4.42</td>
<td>0.03</td>
<td>3.43</td>
<td>27.00</td>
<td>0.94</td>
<td>6.29</td>
</tr>
<tr>
<td>QTRSEXP</td>
<td>213</td>
<td>41.25</td>
<td>1.28</td>
<td>1.00</td>
<td>101.00</td>
<td>21.30</td>
<td>453.71</td>
</tr>
<tr>
<td>WILQIND</td>
<td>213</td>
<td>36.75</td>
<td>0.61</td>
<td>5.00</td>
<td>65.00</td>
<td>10.14</td>
<td>102.86</td>
</tr>
<tr>
<td>WEITZ</td>
<td>213</td>
<td>114.15</td>
<td>4.48</td>
<td>17.45</td>
<td>268.05</td>
<td>74.34</td>
<td>5525.46</td>
</tr>
</tbody>
</table>

* Some senior Enginemen had no record of AFQT Score.

Figure 3.4  Simple Statistics for Variables Used in Analysis
overall R-square value for the entire model and each regression coefficient was tested against the p<.05 criterion of statistical significance. The overall null hypothesis is that the independent personnel variables are not significantly related to total CASREP downtime.

To cross-validate the regression results, the total data set containing 213 cases was divided into two parts, one containing 2/3 of the total (n=142), subsequently called the predictor sample. This sample was used to develop an equation for total downtime as a function of the independent variables. The equation developed was then used to predict the total downtime for the smaller portion of the total data set containing 1/3 of the total (n=71), subsequently referred to as the test sample. The cross-validity correlation between the actual downtime for the test sample and the predicted downtime for the test sample was calculated to determine the accuracy of the developed equation.

Upon completion of the cross-validity correlations, regression analysis was conducted on the entire sample to obtain the most reliable coefficients of regression using the same model as in the cross-validity correlation. The full data set was also used to examine the relationships of the ship effect variable (WEITZ) to the other independent variables in the model, and to develop equations using downtime not awaiting parts (DWNOTHER) and downtime awaiting parts as the dependent variables (DWNSUP).
IV. RESULTS

A. CROSS-VALIDATION

The results of the regression conducted on the predictor sample in the cross-validation study are displayed in figure 4.1.

<table>
<thead>
<tr>
<th>DEPENDENT VARIABLE: DWNTOT</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOURCE</td>
</tr>
<tr>
<td>MODEL</td>
</tr>
<tr>
<td>ERROR</td>
</tr>
<tr>
<td>TOTAL</td>
</tr>
<tr>
<td>R-SQUARE</td>
</tr>
<tr>
<td>ADJ R-SQ</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>INDEPENDENT VARIABLE</th>
<th>COEFFICIENT</th>
<th>T FOR HO: COEFFICIENT=0</th>
<th>SIGNIFICANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTERCEP</td>
<td>52.15</td>
<td>1.473</td>
<td>0.2796</td>
</tr>
<tr>
<td>WEITZ</td>
<td>0.83</td>
<td>6.787</td>
<td>0.0001</td>
</tr>
<tr>
<td>NRHSGRAD</td>
<td>-18.42</td>
<td>-2.624</td>
<td>0.0080</td>
</tr>
<tr>
<td>NRAUXTEX</td>
<td>9.62</td>
<td>1.469</td>
<td>0.3101</td>
</tr>
<tr>
<td>NRACTEX</td>
<td>-20.07</td>
<td>-1.865</td>
<td>0.0460</td>
</tr>
<tr>
<td>NRNONNEC</td>
<td>14.18</td>
<td>1.938</td>
<td>0.0938</td>
</tr>
<tr>
<td>QTRSEXP</td>
<td>0.87</td>
<td>1.629</td>
<td>0.1036</td>
</tr>
</tbody>
</table>

Figure 4.1 Results of Regression--Predictor Sample

4.1. The control variable WEITZ, the quality measure NRHSGRAD, and the number of air conditioning technicians NRACTEX are significant and in the expected direction in the equation developed from the predictor sample. The coefficients of regression for all the variables were multiplied by the respective independent variables in the test sample to obtain predicted downtime for the test sample. Then the correlation between the predicted and actual downtime was
calculated. If the equation developed using the predictor sample is reliable for the test sample, the correlation between the predicted downtime and the actual downtime in the test sample should be very close to or equal to the coefficient of correlation in the predictor sample (R=.606).

### CORRELATION MATRIX

<table>
<thead>
<tr>
<th></th>
<th>YHAT</th>
<th>DWNTOT</th>
</tr>
</thead>
<tbody>
<tr>
<td>YHAT</td>
<td>1.00000</td>
<td>0.68423</td>
</tr>
<tr>
<td>DWNTOT</td>
<td>0.68423</td>
<td>1.00000</td>
</tr>
</tbody>
</table>

Note: Numbers below correlations are two tailed significance levels.

Figure 4.2 Results of Cross-Validity Analysis

The cross-validity analysis is displayed in figure 4.2. The predicted total downtime is variable YHAT and the actual total downtime is variable DWNTOT. As shown in the figure, the test sample correlation is r=.684, very close to (in fact higher than) .606, the expected value. This result confirms that the developed model is reliable in predicting the actual downtime based on the independent variables.

**B. FULL SAMPLE REGRESSION ANALYSIS**

The results of the regression conducted on the full sample (n=213) are shown in figure 4.3. The resulting R-square value for the equation is .4134, corresponding to a multiple correlation of r=.64. The expected relationships
DEPENDENT VARIABLE: DWNTOT

<table>
<thead>
<tr>
<th>SOURCE DF</th>
<th>F VALUE</th>
<th>PROB&gt;F</th>
</tr>
</thead>
<tbody>
<tr>
<td>MODEL 6</td>
<td>24.196</td>
<td>0.0001</td>
</tr>
<tr>
<td>ERROR 206</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL 213</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| R-SQUARE | 0.4134 |
| ADJ R-SQ | 0.3963 |

VARIABLE COEFFICIENT T FOR HO: COEFFICIENT=0 SIGNIFICANCE

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>COEFFICIENT</th>
<th>T FOR HO: COEFFICIENT=0</th>
<th>SIGNIFICANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTERCEP</td>
<td>46.657</td>
<td>1.227</td>
<td>0.2211</td>
</tr>
<tr>
<td>WEITZ</td>
<td>0.87</td>
<td>9.549</td>
<td>0.0001</td>
</tr>
<tr>
<td>NRHSGRAD</td>
<td>-23.57</td>
<td>-4.313</td>
<td>0.0001</td>
</tr>
<tr>
<td>NRAUXTEX</td>
<td>-13.58</td>
<td>1.871</td>
<td>0.0627</td>
</tr>
<tr>
<td>NRACTEX</td>
<td>-14.04</td>
<td>-1.806</td>
<td>0.0724</td>
</tr>
<tr>
<td>NRNONNEC</td>
<td>16.97</td>
<td>2.656</td>
<td>0.0085</td>
</tr>
<tr>
<td>*QTRSEXP</td>
<td>1.07</td>
<td>2.332</td>
<td>0.0114</td>
</tr>
</tbody>
</table>

*Counter-intuitive result

Figure 4.3 Results of Full Sample Regression

with total downtime (DWNTOT) are present in the case of NRHSGRAD and NRNONNEC, as well as the control variable (WEITZ). The results indicate that increasing the number of enginemen who are high school graduates (variable NRHSGRAD) onboard the FFG-7 class ships would result in decreased total downtime. Similarly, reducing the number of untrained enginemen onboard (variable NRNONNEC) would also reduce total downtime. However, counter-intuitive results were obtained in the case of the experience measure (variable QTRSEXP). The full model regression indicates that experience is directly, rather than inversely, related to total downtime. Unfortunately, the variables NRAUXTEX and NRACTEX are not significant in the full-sample regression model. Thus, the full regression model does not identify which type of trained engineman (auxiliary trained or air conditioning
Figure 4.4 Results of Regression with Dependent Variables DWNTOT and DWNSUP

trained) we should add to obtain the the decrease in readiness indicated by reducing the number of untrained individuals onboard.

The full model was also used in regression analysis to examine the relationship of the personnel characteristics to
the components of total downtime (variables DWNSUP and DWNOTHER). The results are displayed in figure 4.4. Surprisingly, personnel characteristics are more strongly associated with downtime awaiting parts (variable DWNSUP) than with downtime not awaiting parts (variable DWNOTHER). This finding may be a result of the ship class maintenance plan, Modular Scheduled Repair, which periodically replaces equipments based on a predetermined failure rate and calls for much of the maintenance on these ships to be accomplished ashore [Ref. 16]. The replacement of complete equipments may eliminate a significant amount of equipment disassembly and troubleshooting. Repair work accomplished by repair activities ashore should generally be accomplished faster than aboard the ship because of their superior maintenance facilities. Both of these cases would reduce DWNOTHER separately and independently of the personnel characteristics of the maintenance personnel onboard.

The control variable WEITZ is, as expected, directly related to both DWNSUP and DWNOTHER. The quality measure, NRHSGRAD, is the only variable inversely related to both DWNSUP and DWNOTHER. Apparently personnel quality is an important determinant for all categories of downtime on the individual ships. NRACTEX is inversely related to DWNSUP but not to DWNOTHER. Training as indicated by the number of trained air conditioning technicians is related significantly in the expected direction to downtime awaiting parts but not to downtime other. The number of untrained technicians is significant and in the expected direction in the model for downtime other but not for downtime awaiting parts. These anomalous training results may reflect multicollinearity among the three training variables (NRAUXTEX, NRACTEX, and NRNONNEC).

In any case, these results raise more questions than they resolve, but certainly they point out the complexity of
the relationships among personnel quantity, quality, training, and experience. At a minimum these results provide support to the belief that personnel characteristics can affect downtime awaiting parts. As in the full regression model, the effects of WEITZ and NRHSGRAD are in the expected direction and significant: the dependent variables increase with an increase in average downtime and decrease with an increase in number of the number of high school graduates onboard. The significant positive relationship of the number of untrained enginemen (variable NRNONNEC) with total downtime not awaiting parts (variable DWNOTHER) seems to indicate that larger numbers of untrained personnel cannot make up for a lack of training in equipment troubleshooting and repair and, therefore, downtime other increases. The significant positive coefficient of the number of auxiliary technicians (NRAUXTEX) in the model with DWNOTHER as the dependent variable is a counter-intuitive result, possibly due to multicollinearity. This together with the counter-intuitive result obtained in the regression on total downtime (DWNTOT), deserves special examination.

C. ANALYSIS OF COUNTER-INTUITIVE RESULTS

The counter-intuitive results obtained in this study prompted further investigation to determine why they occurred. This investigation involved analysis of the correlations between the independent variables of interest and the control variable WEITZ. Figure 4.5 displays the correlations of interest between the control and the other independent and dependent variables. Among these, two strong, significant correlations are evident. The variable of primary interest, NRAUXTEX, has a significant negative correlation ($r=-.31$) with average ship downtime (WEITZ), and the number of enginemen with no NEC assigned (NRNONNEC) has
### Figure 4.5 Correlations between the Variables in the Model

A significant positive correlation ($r = .32$) with average ship downtime (both significant at the .0001 level). These results indicate that, as the number of auxiliary technicians increases, the average downtime decreases, and, as the number of untrained enginemen onboard increases, the average downtime increases. Further evidence that increases in the numbers of auxiliary technicians (variable NRAUXTEX) decrease total downtime is the simple correlation of NRAUXTEX with DWNTOT, which is $-.16$, in the expected direction and significant at the .01 level. What appears to be happening in the full regression model is that the intuitively acceptable effects are being loaded on the independent variables with the largest variances, leaving the independent variables with less variance to show...
counter-intuitive or insignificant results. The strong correlation of the variable NRAUXTEX with the control variable WEITZ indicates that the number of auxiliary technicians is particularly significant in its effect on differences in total downtime among ships.

The remaining counter-intuitive result—that total downtime (variable DWNTOT) increases as experience onboard (variable QTRSEXP) increases—may be due to selective attrition of quality personnel within a ship over time. The quality-attrition hypothesis is consistent with the large inverse within-ship effect of NRHSGRAD on DWNTOT in the full regression model. What appears to be happening is an attrition over time of high school graduates, that leaves fewer high school graduates among the more experienced personnel aboard a ship. This progressive reduction in quality thus increases total ship downtime.
V. CONCLUSIONS AND RECOMMENDATIONS

The results of this analysis support the findings of prior studies that the relationships between materiel readiness and personnel characteristics are complex and fraught with collinearity and interaction. Here again, ship effect variables appear more strongly associated with CASREP downtime than the personnel variables do. Downtime awaiting parts for auxiliary equipments on the FFG-7 class tends to be more predictable using personnel variables than downtime not awaiting parts. Downtime awaiting parts alone accounts for 64 percent of total downtime in this study. This finding could lead to the conclusion that a greater reduction in total downtime would result from expenditures for additional supply parts than for expenditures in the personnel management area. For an example, see [Ref. 17].

The process of selecting a part to stock for future unknown and possibly unknowable casualties from the nearly infinite variety of parts available rapidly diminishes the readiness returned from expenditures in the supply area. For this reason, even though personnel characteristics only account for approximately 15 percent of the variance in total downtime in this study, achieving improved readiness through improvement of personnel management seems more likely in the long term than expenditures in the supply area. While the purchased repair part sits in a bin, awaiting its chance to contribute to readiness, the trained maintenance technician can contribute to the solution of every maintenance problem.

The analysis conducted here indicates that the alterations in personnel policy most likely to decrease auxiliary equipment downtime onboard the FFG-7 class are increasing the number of high school graduates onboard and decreasing
the number of enginemen without specialized training resulting in an Navy Enlisted Classification (NEC). While increasing the number of auxiliary technicians (NEC 4381 and 4382) is not indicated directly by the full model, the strong negative correlation with average total downtime for each ship offers separate and strong evidence that increasing the number of auxiliary technicians onboard the FFG-7 class ships would reduce downtime as well. Failure of this variable to relate significantly to total downtime in the full regression analysis may be because auxiliary maintenance technician efforts are represented by the control variable, average ship quarterly downtime. Expressed in a different manner, the number of auxiliary technicians is a good indicator of differences in average downtime among ships. Increases in the number of auxiliary technicians should be associated with decreases in downtime. While, among the personnel variables, the number of high school graduates on a ship was the most significantly and consistently related to a reduction of auxiliary equipment downtime within a ship over quarters, it was not related to ship downtime averaged over quarters, as the number of auxiliary technicians was.

Experience, as measured by the time onboard a single ship, was directly, rather than inversely, related to CASREP downtime. One possible reason for this counter-intuitive result is selective attrition of superior enginemen to the gas turbine ratings or from military service. If this is in fact the case, a policy change to increase incentives for enginemen to stay in the rating may be indicated to support new diesel main propulsion ships and the growing auxiliary maintenance role for enginemen on gas turbine ships.

Interviews conducted with detailers in the preparation of this thesis indicated that in assignment of personnel to billets requiring Navy Enlisted Classifications, the billet
APPENDIX E
SAMPLE REGRESSION PROGRAM

DATA ONE;
  SET CASNPERS.FINALMR;
  IF TYPE = 3;
  IF TUIC = '106' OR TUIC = '052' OR TUIC = '054' OR TUIC = '699' THEN DELETE;
  PROC REG SIMPLE DATA=ONE;
  MODEL DWNTOT = WEITZ NRAUXTEX;
  MODEL DWNTOT = NRAUXTEX NRHSGRAD;
  MODEL DWNTOT = NRAUXTEX NRACTEX;
  MODEL DWNTOT = NRAUXTEX NRHSGRAD;
  MODEL DWNTOT = NRAUXTEX QTRSEXP;
  MODEL DWNTOT = NRHSGRAD;
  MODEL DWNTOT = QTRSEXP;
  MODEL DWNTOT = WEITZ;
  MODEL DWNTOT = NRAUXTEX;
  MODEL DWNTOT = NRACTEX;
  MODEL DWNTOT = NRNONNEC;
  MODEL DWNTOT = NRHSGRAD;
  MODEL DWNTOT = QTRSEXP;
  PROC MEANS DATA=ONE MAXDEC=2 N MEAN STDERR MIN MAX SUM STD VAR;
  VAR DWNTOT DWNSUP DWNOTHER MNAPQT MNCURAGE MNHYEC MNTOB
  MNYRADS NRACTEX NRAUXTEX NRHSGRAD NRNONNEC MNPAYGRD QTRSEXP
  WILCOX; PROC CORR DATA=ONE OUTP=TW0;
  VAR DWNTOT DWNSUP DWNOTHER NRAUXTEX NRACTEX NRNONNEC
  NRHSGRAD QTRSEXP WEITZ; PROC PRINT DATA= TWO; /*  */

53
The output data set contained the following variables: 

- TUIC -- a ship identifier
- QTR -- the quarter number
- DOWNSUP -- the time awaiting parts
- DOWNOTHER -- the downtime not awaiting parts
- DOWNTOT -- the total CASREP downtime during the quarter
- MNAFQT -- the mean of the AFQT scores
- MNPAYGRD -- the mean of the rate of the Enginemen onboard
- QTRSEXP -- the sum of the total quarters served onboard the ship by the Enginemen onboard
- NRACTEX -- number of Air conditioning techs onboard in the quarter
- NRAUTGR -- number of auxiliary technicians (NOC 4381/4382) onboard in the quarter
- NRHGGRAD -- the number of high school graduates onboard
- WILQIND -- a variable generated by summing the DMDC codes for the rate of the Engineman onboard (E-7 is equal to 7, E-1 to 1, etc.).
APPENDIX D
PROGRAMS FOR MERGING PERSONNEL AND CASREP DATA

The program below creates a summary output of the casrep data which includes the ship unit identification code, the quarter and the total equipment downtime in days, the time awaiting parts, and the time down not awaiting parts which is merged matching ship and quarter with the personnel data. The next portion of the program merges the personnel and casrep information matching the data by ship and quarter.

DATA ONE:
INFILE CASREP;
INPUT QTR 2.
TUIC $CHAR3.
REPDAT YYMDD6.
CORDAT YYMDD6.
SEVER \$.
SUPDAY 6.
REPLEV 1.
EIC $4.
CAS 2.
OTHDAY 2.;

DATA TWO:
SET ONE:
IF TUIC=' 28' THEN TUIC='028';
IF TUIC=' 32' THEN TUIC='032';
IF TUIC=' 33' THEN TUIC='033';
IF TUIC=' 34' THEN TUIC='034';
PROC SUMMARY DATA=TWO; CLASS TUIC QTR;
Var SUPDAY CAS OTHDAY;
OUTPUT OUT=SUMREP.CASSUM;
SUM= DWNSUP DWNTOT DWNOTHER;

DATA FOUR:
SET SUMREP.CASSUM;
IF TYPE NE 3 THEN DELETE;

DATA FIVE:
LENGTH TUIC 3.;
SET PERSON.PERSUM;
IF TYPE NE 3 THEN DELETE;
TUIC = SUBSTR(UIC,4 3);
PROC SORT DATA=FOUR; BY TUIC QTR;
PROC SORT DATA=FIVE; BY TUIC QTR;

DATA SIX:
MERGE FOUR FIVE; BY TUIC QTR;
PROC SORT DATA=SIX OUT=CASN PERS.ALEMERG; BY TUIC QTR;
PROC PRINT DATA=CASN PERS.ALEMERG;
* For multi-quarter report, first quarter coverage

IF ST LE REPDATE AND REPDATE LE EN AND CORDATE GT EN THEN DO;
    CAS = EN - REPDATE;
END;

* For multi-quarter report, middle qtr coverage

IF ST GE REPDATE AND CORDATE GE EN THEN DO;
    CAS = EN - ST;
END;

* For multi-quarter report, last quarter coverage

IF EN GE CORDATE AND ST LE CORDATE AND ST GT REPDATE THEN DO;
    CAS = CORDATE - ST;
END;

* For single quarter report, calculate coverage

IF ST LE REPDATE AND CORDATE LE EN THEN DO;
    CAS = CORDATE - REPDATE;
END;

* Calculate total report coverage

CASTOT = SUM(OF CAS1-CAS19);

* Generate weekly supply coverage

DO OVER CAS:
    IF CASTOT GE 0:
        SUPDAY = (SUPHR/24)*CAS/CASTOT;
        IF SUPDAY GE CAS THEN SUPDAY=CAS;
        FILLER= (CAS-SUPDAY);
        IF FILLER GE 0 THEN OTHDAY=FILLER; ELSE OTHDAY= 0;
    END;

FILE DATAGOUT:
DO OVER CAS:
    IF CAS GT 0 THEN
        PUT @1 I 2.
        @4 UTC 3.
        @6 REPDATE YYMMD6.
        @16 CORDATE YYMMD6.
        @24 SEVER 1.
        @26 SUPDAY 6:1
        @34 REPLEV 1.
        @36 EIC $4.
        @41 CAS 2.
        @46 OTHDAY 2.;

END;
APPENDIX C
CASREP DATA PROCESSING PROGRAMS

The program below inputs the start and ending date for each of the nineteen quarters, and calculates the total downtime, downtime awaiting parts and downtime other (i.e. not awaiting parts) for each of the nineteen quarters.

DATA QUARTER:
INFORMAT Q1-Q38 YYYMD6.;
INPUT Q1-Q38;
CARDS:
791001 791231
800101 800331
800401 800630
800701 800930
810101 810331
810401 810630
810701 810930
811001 811231
820101 820331
820401 820630
820701 820930
821001 821231
830101 830331
830401 830630
830701 830930
831001 831231
840101 840331
840401 840630

Sample of CASREP1 data

INPUT UIG REPDATE CORDATE SEVER SUPHR REPLEV EIC $;
028 780404 780414 2 240 1 YCO4 ;
028 780404 780501 2 480 1 IB03 ;

ALOHA:
SET JOKE.CASREP1;
SUPHR= ABS(SUPHR);
IF CORDATE GE 7213;
IF REPDATE LE 8947: DATA CASREP;
IF N EQ 1 THEN SET QUARTER;
SET ALOHA;
* ST: quarter starting dates
* EN: quarter ending dates
* CAS: proportion of quarter covered by CASREP
VAR HYEC AFQT PAYGRD CURAGE YRADS TOB NECFLAG ACFLAG HSGFLAG
OUTPUT OUT=PERSON.PERSUM
MEAN=MNHYEC MNAFQT MNPAYGRD MNCURAGE MNYRADS MNTOB
SUM(NECFLAG)=NRAUXTEX SUM(ACFLAG)=NRACTEX
SUM(HSGFLAG)=NRHSGRAD SUM(TOB)=OTRSEX
SUM(PAYGRD)=WILQIND OPTIONS LINESIZE=80 PROC PRINT DATA=
PERSON.PERSUM TITLE FINAL PROC SUMMARY WITH EN'S ONLY FROM EN
DATA SET TITLE2 WITH VAR DESIRED FOR REGRESSION /* */
The portion of the program below generates a Time on Board figure for each individual in the data set. This variable indicates the number of quarters each individual has been onboard the FFG to which he is currently assigned. If the individual goes from one FFG to another, the variable will reflect the number of quarter spent on both ships. If the individual is on an FFG of interest in the early periods, goes ashore or to another class ship and returns to another FFG, the time on variable is restarted for the second tour on an FFG.

```
DATA ONE;
    INPUT HYEC 1-2
          AFQT 3-5
          PAYGRD 6
          CURAGE 7-8
          PMOS $CHAR7.
          YRADS 16-17
          UIC $CHAR6.
          DMOS $CHAR7.
          START 31-31
          TR 33-34
          SASE 35-37;
    TOB = QTR - START + 1;
DATA TWO1 SET ONE*
    IF SUBSTR(PMS,I,1,'F') EN';
    PROC SORT DATA=TWO OUT=SEAM.FFGFMN;
    BY UIC QTR PAYGRD;
    OPTIONS LINESIZE= 80;
    PROC PRINT DATA = SEAM.FFGFMN;
```

The program below uses the input personnel data and provides an output summary of the desired data on each ship for each quarter.

```
DATA ONE; SET PERS.PERFFG;
    IF SUBSTR(PMOS,1,2) = 'EN';
    NEC=SUBSTR(PMOS,4,4);
    TUIC=SUBSTR(UIC,4,3); DATA TWO;
    SET ONE;
    IF NEC='4381' OR NEC='4382' THEN NECFLAG=1; ELSE NECFLAG=0;
    IF NEC='4294' THEN ACFLAG=1; ELSE ACFLAG=0;
    IF HYEC GE 6 THEN HSGFLAG=1; ELSE HSGFLAG=0;
    DROP PMOS DMOS;
    OPTIONS LINESIZE=80; PROC SUMMARY DATA=TWO;
    CLASS UIC QTR;
```
ARRAY CURAGE  CURAGE1 CURAGE2 CURAGE3 CURAGE4 CURAGE5
                CURAGE6 CURAGE7 CURAGE8 CURAGE9 CURAGE10
                CURAGE11 CURAGE12 CURAGE13 CURAGE14 CURAGE15
                CURAGE16 CURAGE17 CURAGE18 CURAGE19;
ARRAY PMOS     PMOS1 PMOS2 PMOS3 PMOS4 PMOS5
                PMOS6 PMOS7 PMOS8 PMOS9 PMOS10
                PMOS11 PMOS12 PMOS13 PMOS14 PMOS15
                PMOS16 PMOS17 PMOS18 PMOS19;
ARRAY YRADS    YRADS1 YRADS2 YRADS3 YRADS4 YRADS5
                YRADS6 YRADS7 YRADS8 YRADS9 YRADS10
                YRADS11 YRADS12 YRADS13 YRADS14 YRADS15
                YRADS16 YRADS17 YRADS18 YRADS19;
ARRAY UIC      UIC1  UIC2  UIC3  UIC4  UIC5
                UIC6  UIC7  UIC8  UIC9  UIC10
                UIC11 UIC12 UIC13 UIC14 UIC15
                UIC16 UIC17 UIC18 UIC19;
ARRAY DMOS     DMOS1 DMOS2 DMOS3 DMOS4 DMOS5
                DMOS6 DMOS7 DMOS8 DMOS9 DMOS10
                DMOS11 DMOS12 DMOS13 DMOS14 DMOS15
                DMOS16 DMOS17 DMOS18 DMOS19;
DO OVER HYEC;
    IF HYEC GT 0 THEN DO;
        START = I;
        GOTO LABEL1;
    END;
END;
LABEL1: FILE DATAOUT;
DO OVER HYEC;
    IF HYEC GT 0 THEN DO;
        PUT _-_;
        HYEC 1-2
        AFQT 3-5
        PAYGRD 7-8
        CURAGE $CHAR7.
        YRADS 16-17
        UIC  $CHAR6.
        DMOS $CHAR7.
        START 31-32
        OTR  33-34
        _N_  35-37;
    END;
END;
APPENDIX B
PERSONNEL DATA PROGRAMS

The program below selects Enginemen on the FFG7 class ships from a cohort data base provided by Defense Manpower Data Center, Lt. Jim Moody and Bill King. The desired information is obtained for the 19 quarters of interest (79Q4 through 84Q2), arrayed over each variable, then the data is swept iteratively to create another file which contains an observation for each of the engineman on the ships for each quarter. The procedure also generates the reporting aboard quarter for each individual, which is the first record in which the appears in the data base for a particular unit.

DATA CLOSER;
INFILE DATAIN;
INPUT
@65   HYEC1  PIB1.
@66   AFQT1  PIB1.
@67   PAYGRD1 PIB1.
@68   CURAGE1 PIB1.
@69   PMOS1  $CHAR7.
@112  YRADS1 PIB1.
@123  UIC1   $CHAR6.
@132  DMOS1  $CHAR7.
...(data from the intervening quarters)...
@1865  HYEC19 PIB1.
@1866  AFQT19 PIB1.
@1867  PAYGRD19 PIB1.
@1887  CURAGE19 PIB1.
@1888  PMOS19 $CHAR7.
@1923  YRADS19 PIB1.
@1932  DMOS19 $CHAR7.; DATA TWO;
SET CLOSER;
ARRAY HYEC   HYEC1 HYEC2 HYEC3 HYEC4 HYEC5
    HYEC6 HYEC7 HYEC8 HYEC9 HYEC10
    HYEC11 HYEC12 HYEC13 HYEC14 HYEC15
    HYEC16 HYEC17 HYEC18 HYEC19;
ARRAY AFQT   AFQT1 AFQT2 AFQT3 AFQT4 AFQT5
    AFQT6 AFQT7 AFQT8 AFQT9 AFQT10
    AFQT11 AFQT12 AFQT13 AFQT14 AFQT15
    AFQT16 AFQT17 AFQT18 AFQT19;
ARRAY PAYGRD PAYGRD1 PAYGRD2 PAYGRD3 PAYGRD4 PAYGRD5
    PAYGRD6 PAYGRD7 PAYGRD8 PAYGRD9 PAYGRD10
    PAYGRD11 PAYGRD12 PAYGRD13 PAYGRD14 PAYGRD15
    PAYGRD16 PAYGRD17 PAYGRD18 PAYGRD19;
SUBSTR -- SAS program function.
SUMREP--Data set name in SAS programs.
SUPDAY--variable name used in SAS programs.
SUPHR --variable name used in SAS programs.
TOB --variable name used in SAS programs.
TUIC --variable name used in SAS programs.
UIC-- Unit Identification Code--an unique number for each ship.
WEITZ--a control variable used in analysis equal to the ship's average downtime.
WILQIND--variable used in SAS programs.
YHAT--variable used in analysis, the predicted value of total downtime for the test sample using the equation developed by the predictor sample.
YRADS --variable used in SAS programs.
NEOCS -- Navy Enlisted Occupational Classification System, which manages the numerous ratings and NEC's which identify Navy skills and requirements.
NMPC--Naval Military Personnel Command.
NODAC --Navy Occupational Data Analysis Center.
NPRDC -- Navy Personnel Research and Development Center.
NPS --Naval Postgraduate School
NRACTEX -- variable used in analysis equal to the number of air conditioning technicians (NEC 4294) onboard a unit in a quarter.
NRAUXTEX --variable used in analysis equal to the number of auxiliary technicians (NEC 4381 and 4382) onboard a unit in a quarter.
NRHSGRAD --variable used in analysis equal to the number of high school graduates among the engineman rating on a ship in a quarter.
NRNONNEC --variable used in analysis equal to the number of enginemen onboard a unit who have no NEC indicating specialized training.
OTHDAY --variable used in SAS programs.
PERFFG --data set name used in programs.
PERSUM --data set name used in programs.
PROB -- abbreviation for probability in regression figures.
QTR --program variable name.
QTRSEXP --variable used in analysis equal to the total number of quarters the enginemen have spent onboard the unit to which they are assigned.
REPDATE--variable used in SAS programs.
REPLEV --variable used in SAS programs.
SMD --Ship Manning Document which establishes the manning requirements for ships.
SPCC--Ships' Parts Control Center
ST --SAS program variable name.
DWNSUP -- variable used in analysis equal to the number of
days in a quarter that the ship was awaiting parts for inop-
erative equipment reported by CASREP.

DWNTOT -- variable used in analysis equal to the total days
downtime for a ship in a quarter.

EIC -- equipment identification code, an alphanumeric iden-
tifier of equipment.

EM -- a rating or occupation in the U.S.NAVY, electrician's
mate.

EN -- a rating or occupation in the U.S.NAVY, engineman.

ENC -- a chief petty officer (paygrade E-7) in the engineman
rating.

ENFN -- a fireman (paygrade E-3) who is designated in the
engineman rating.

Engineman -- a rating or occupation in the U.S. NAVY which
performs maintenance on diesel engines and has secondary
duties of auxiliary equipment maintenance.

FFG -- Guided missile frigate.

FN -- fireman who is not designated for any specific rating.

FT -- abbreviation for Fire control Technician.

GT -- abbreviation for Greater Than in SAS programs

HSGFLAG -- variable name in SAS programs

HYEC -- variable in SAS programs and DMDC date element name.

IC -- abbreviation for Interior Communications technician, a
NAVY rating.

IMA -- Intermediate Maintenance Activity, an off ship repair
facility which repairs equipment casualties beyond the capa-
bility of the ship.

INTERCEP -- intercept of the y-axis in the regression equa-
tion.

ISD -- Instructional Systems Development.

LE -- SAS function "less than or equal to."

NEC -- Navy Enlisted Classification; a code which identifies
specific skills.

NECFLAG -- A variable in the SAS programs.
APPENDIX A
GLOSSARY

ABS - SAS program absolute value function.
ACFLAG - SAS program variable.
ADJ - abbreviation for adjusted in the regression printout figures.
AFQT - Armed Forces Qualification Test score.
ALLEMERG - program data set name.
ARPA -- Advanced Research Projects Agency
Auxiliariesman -- name used for 1975 proposed auxiliary maintenance technician.
CASREPS -- CASualty REPorts which provide information on equipment which is inoperative and affects the ability of a unit to fulfill its mission.
CAS -- SAS program variable name.
CASNPERS -- Data set name.
CASSUM -- Data set name.
CASTOT -- SAS program variable.
CIN -- Computer Identification Number for training courses.
CORDATE -- Variable in CASREP processing program.
Cryogenic -- Liquid gas generation systems.
CURAGE -- current age of enginemen on FFG 7 class.
DATAIN -- data set name in programs.
DATAOUT -- data set name in programs.
DMDC -- Defense Manpower Data Center
downtime -- the number of days between the report date of the CASREP and the date the casualty is reported corrected.
DWNOTHER -- variable used in analysis equal to the total downtime in a quarter minus the downtime awaiting parts (DWNTOT - DWNSUP).
is considered filled when a match in rating and paygrade is achieved. Only secondary consideration is given to filling the billet with a man holding the required NEC. Based on the analysis here, a reduction in CASREP downtime would occur if the detailing process were modified to fill the NEC requirement as well as the rating and paygrade requirements. Modification of the existing supporting computer systems to accomplish this search for a job-skill match between NEC requirements and the pool of eligibles for transfer could result in a significant reduction in downtime. It may well be that such a method could produce a substantial increase in the fleet-wide fill ratio of NEC billets, without additional training and the requirement to fund it. Ship readiness would benefit.

This analysis examined a model relating training, quality, and experience to CASREP downtime. The regression analysis conducted indicates that for every additional engineman high school graduate assigned to an FFG 7 class ship, CASREP downtime for auxiliary equipments should decrease approximately 20 days per quarter. The reduction in downtime associated with the assignment of an additional auxiliary technician to an FFG-7 class ship is approximately 15 days per quarter. The best policy, of course, is to send high school graduates for training resulting in the NEC, combining both quality and training, to reduce downtime.

The analysis conducted here provides evidence that total auxiliary equipment downtime could be decreased onboard the FFG-7 class by increased placement of trained enginemen onboard (NEC's 4381, 4382, and 4294). The evidence presented in this study indicates that a reduction in downtime is achieveable either by improved management of existing NEC's or by implementation of a new auxiliary equipment rating.
APPENDIX F
DESCRIPTION OF PERMANENT DATA BASE

A data base was established on permanent mass storage and on magnetic tape at Naval Postgraduate School. The data is in two forms: 1) the raw data on enginemen and non-designated firemen on the ships covered in this thesis, and 2) a data base created using Statistical Analysis System (SAS) software in the analysis for this thesis containing: information on CASREPS of auxiliary equipments on FFG-7 class ships covered in this thesis as received from American Management Systems Incorporated, and the merged file of CASREP and Personnel information on the ships covered in this analysis. These data bases are described in detail below.

A. RAW DATA

The personnel data on Enginemen (EN) and non-designated firemen (FN) is a binary file which has a logical record length of 1954 card columns. Each record is an observation on one individual which gives personal information on that person over the nineteen quarters covered in the analysis (October 1979 through June 1984). Each record is a series of repeated information on each individual. If the individual was not on one of the ships in the study conducted here, the card columns for that quarter contain filler zeros. The blocks contain personnel information for the people on the ships as indicated below:

<table>
<thead>
<tr>
<th>Card columns</th>
<th>Quarter covered</th>
</tr>
</thead>
<tbody>
<tr>
<td>55-154</td>
<td>OCT-DEC 1979</td>
</tr>
<tr>
<td>155-254</td>
<td>JAN-MAR 1980</td>
</tr>
<tr>
<td>255-354</td>
<td>APR-JUN 1980</td>
</tr>
<tr>
<td>355-454</td>
<td>JUL-SEP 1980</td>
</tr>
<tr>
<td>455-554</td>
<td>OCT-DEC 1980</td>
</tr>
<tr>
<td>555-654</td>
<td>JAN-MAR 1981</td>
</tr>
<tr>
<td>655-754</td>
<td>APR-JUN 1981</td>
</tr>
<tr>
<td>755-854</td>
<td>JUL-SEP 1981</td>
</tr>
<tr>
<td>855-954</td>
<td>OCT-DEC 1981</td>
</tr>
<tr>
<td>955-1054</td>
<td>JAN-MAR 1982</td>
</tr>
<tr>
<td>1055-1154</td>
<td>APR-JUN 1982</td>
</tr>
<tr>
<td>1155-1254</td>
<td>JUL-SEP 1982</td>
</tr>
<tr>
<td>1255-1354</td>
<td>OCT-DEC 1982</td>
</tr>
<tr>
<td>1355-1454</td>
<td>JAN-MAR 1983</td>
</tr>
<tr>
<td>1455-1554</td>
<td>APR-JUN 1983</td>
</tr>
<tr>
<td>1555-1654</td>
<td>JUL-SEP 1983</td>
</tr>
<tr>
<td>1655-1754</td>
<td>OCT-DEC 1983</td>
</tr>
<tr>
<td>1755-1854</td>
<td>JAN-MAR 1984</td>
</tr>
<tr>
<td>1855-1954</td>
<td>APR-JUN 1984</td>
</tr>
</tbody>
</table>

The information contained in each quarterly record is as follows:

<table>
<thead>
<tr>
<th>Card column</th>
<th>Information Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>51</td>
<td>Unique Identification Number</td>
</tr>
<tr>
<td>52</td>
<td>Renorm Flag</td>
</tr>
<tr>
<td>53-54</td>
<td>Filler</td>
</tr>
<tr>
<td>55-58</td>
<td>Unique Identification Number</td>
</tr>
<tr>
<td>59-60</td>
<td>Total Active Federal Military Service</td>
</tr>
<tr>
<td>61-62</td>
<td>DOD Primary Occupation Group</td>
</tr>
<tr>
<td>63-64</td>
<td>DOD Duty Occupation Group</td>
</tr>
<tr>
<td>65</td>
<td>Highest Year of Education</td>
</tr>
<tr>
<td>66</td>
<td>APQT Percentile</td>
</tr>
<tr>
<td>67</td>
<td>Paygrade</td>
</tr>
</tbody>
</table>
and similarly for intervening quarters.

1855-1954 Information on individual for last quarter of the study as indicated in paragraph above.

B. SAS Files

The SAS file containing CASREP information is stored on magnetic tape number 588 under the following name: WILLIS.SAS.CASREP. This file contains the following information:

<table>
<thead>
<tr>
<th>Label</th>
<th>Name Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>CORDATE</td>
<td>Casualty correction date YYMMD</td>
</tr>
<tr>
<td>REPDATE</td>
<td>Casualty report date YYMMD</td>
</tr>
<tr>
<td>SEVFR</td>
<td>1=C-2, 2=C-3, 3=C-4</td>
</tr>
<tr>
<td>SUPHR</td>
<td>Downtime awaiting parts in Hours.</td>
</tr>
<tr>
<td>UIC</td>
<td>Ship Unit Identification Code</td>
</tr>
<tr>
<td>EIC</td>
<td>Equipment Identification Code</td>
</tr>
<tr>
<td>NOMEN</td>
<td>Abbreviated equipment name.</td>
</tr>
</tbody>
</table>

The SAS file is stored on magnetic tape number 588 and on mass storage 4C under the DATA SET NAME=MSS.F0597.WEITZMAN. The SAS data set name is FINALMR. The data set contains the following information:

55
<table>
<thead>
<tr>
<th>Label Name</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>DWNTOT</td>
<td>Total Downtime in a quarter in days.</td>
</tr>
<tr>
<td>DWNOTHER</td>
<td>Downtime not awaiting parts in a quarter in days.</td>
</tr>
<tr>
<td>DWNSUP</td>
<td>Downtime awaiting parts in a quarter in days.</td>
</tr>
<tr>
<td>WEITZ</td>
<td>Each ship's quarterly average downtime in days.</td>
</tr>
<tr>
<td>QTRSEXP</td>
<td>The sum of the time onboard in quarters the enginemen on a ship have spent on that ship.</td>
</tr>
<tr>
<td>NRAUXTEX</td>
<td>The number of auxiliary technicians (NEC 4381 and 4382) on a ship in a quarter.</td>
</tr>
<tr>
<td>NRACTEX</td>
<td>The number of air conditioning technicians (NEC 4294) on a ship in a quarter.</td>
</tr>
<tr>
<td>NRNONNEC</td>
<td>The number of enginemen on a ship in a quarter without an NEC.</td>
</tr>
<tr>
<td>NRHSGRAD</td>
<td>The number of enginemen on a ship in a quarter who are high school graduates.</td>
</tr>
</tbody>
</table>
LIST OF REFERENCES


8. Ibid., pp. 73-74.


<table>
<thead>
<tr>
<th>No.</th>
<th>Copies</th>
<th>Name and Address</th>
</tr>
</thead>
</table>
| 1.  | 2      | Defense Technical Information Center  
      Cameron Station  
      Alexandria, Virginia 22314 |
| 2.  | 2      | Library, Code 0142  
      Naval Postgraduate School  
      Monterey, California 93943 |
| 3.  | 10     | Commander Naval Sea Systems Command (Code56W4E)  
      Washington, D. C. 20362 |
| 4.  | 1      | American Management Systems, Inc.  
      ATTN: Mr. J. W. Pritchard  
      1777 North Kent Street  
      Arlington, Virginia 22209 |
| 5.  | 1      | Admiral N. R. Fowler, Sr.  
      523 E. Main Street  
      Union, S.C. 29379 |
| 6.  | 2      | Mr. E.L. Willis, Sr.  
      Rt. 1 Box 104  
      Trenton, Tennessee 38382 |
| 7.  | 3      | Professor R. A. Weitzman, Code 54Wz  
      Department of Administrative Science  
      Naval Postgraduate School  
      Monterey, California 93943 |
| 8.  | 2      | Professor Thomas Swenson, Code 54Zw  
      Department of Administrative Science  
      Naval Postgraduate School  
      Monterey, California 93943 |
| 9.  | 1      | Deputy Chief of Naval Operations  
      (Manpower, Personnel and Training)  
      Chief of Naval Personnel (OP-11)  
      Arlington Annex  
      Columbia Pike and Arlington Ridge Road  
      Washington, D.C. 20370 |
| 10. | 3      | Deputy Assistant Secretary of the Navy for Manpower  
      Office of the Secretary of the Navy  
      Washington, D.C. 20350-2000 |
| 11. | 1      | Commanding Officer  
      Naval Reserve Officer Training Unit  
      Cornell University  
      Ithaca, New York 10026 |
END

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