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The effects of the Maintenance Training Improvement Program on unit performance

Tung, James M.

Monterey, California. Naval Postgraduate School

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THESIS

THE EFFECTS OF THE MAINTENANCE TRAINING IMPROVEMENT PROGRAM ON UNIT PERFORMANCE

by

James M. Tung

June, 1993

Thesis Advisor: Alice Crawford
Thesis Co-Advisor: David G. Brown

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A study was conducted to determine whether the Maintenance Training Improvement Program (MTIP) has any relationship to unit performance of the west coast F-14 and E-2 squadrons. Using correlation analysis, the MTIP completion rate was compared with operational measures such as the Full Mission Capable (FMC) rate, the number of no-defect (malfunction code A-799) maintenance actions, and the Direct Maintenance Manhours per Flight Hour (DMMH/FH). A moderate positive correlation was found between the MTIP completion rate and the FMC rate, and a moderately weak negative correlation was found between the MTIP completion rate and the number of A-799 maintenance actions. There was no correlation found between the MTIP completion rate and the DMMH/FH. These relationships have provided some insight with encouraging implications for further research to assess the existing training program.

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The Effects of the Maintenance Training Improvement Program on Unit Performance

by

James M. Tung
Lieutenant Commander, United States Navy
B.S., Northrop Institute of Technology, 1973

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Authors: [redacted]

Approved by: [redacted]

Alice Crawford, Primary Thesis Advisor

[redacted]

David R. Whipple, Chairman
Department of Administrative Sciences

ABSTRACT

A study was conducted to determine whether the Maintenance Training Improvement Program (MTIP) has any relationship to unit performance of the west coast F-14 and E-2 squadrons. Using correlation analysis, the MTIP completion rate was compared with operational measures such as the Full Mission Capable (FMC) rate, the number of no-defect (malfunction code A-799) maintenance actions, and the Direct Maintenance Manhours per Flight Hour (DMMH/FH). A moderate positive correlation was found between the MTIP completion rate and the FMC rate, and a moderately weak negative correlation was found between the MTIP completion rate and the number of A-799 maintenance actions. There was no correlation found between the MTIP completion rate and the DMMH/FH. These relationships have provided some insight with encouraging implications for further research to assess the existing training program.

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I. INTRODUCTION

The world of naval aviation has been in existence for over eighty years since Eugene Ely, a civilian pilot, flew a Curtiss biplane from a wooden ramp built on the forecastle of USS Birmingham (Johnson, 1981). Since then, naval aviation has progressed from canvas framed aircraft with bicycle tires and wooden propellers to highly sophisticated, complex airborne weapons systems. The complexity of modern aircraft in the U.S. Navy requires high levels of knowledge and skill of our technicians who must maintain the various high-tech systems so that the aircraft can perform their intended roles such as air-to-air combat, ordnance delivery, and early airborne warning, just to mention a few.

It is reasonable to believe that well-trained personnel perform better on their jobs than do less-well-trained personnel (Gibson and Orlansky, 1986, pp.5). If this is so, the effects of better training should be observable in such indicators as the amount of direct maintenance manhours required per each flight hour (DMMH/FH), the number of components removed by the Organizational Maintenance Level ("O" Level) technicians as defective that are found to operate properly when tested later (this error is reported as a Malfunction Code A-799), and the operational readiness posture--Full Mission Capable (FMC) rate--for particular aviation units. If the effects of training are not reflected in unit performance and operational readiness, then the existing training program needs to be either improved or replaced by an alternative program. Deficiencies in technical training and personnel qualifications could prevent a technician from acquiring the proper knowledge needed to perform at his or her top efficiency. The purpose of aviation maintenance training is to prepare sailors to perform the technical tasks necessary to assure the availability and proper functioning of aircraft weapons systems and support equipment.

A. SCOPE OF STUDY

In any naval aircraft community, shortages of trained personnel can pose a serious threat to naval air warfare operations. The Maintenance Training Improvement Program (MTIP) establishes an initial level of proficiency and provides a baseline for a tailored training program for improving the knowledge of technicians. However, the program has not been tested to determine whether it is ultimately helping an aviation squadron to maintain or improve its performance at a competitive level. This thesis examines the relationship between MTIP and performance indicators such as DMMH/FH, Code A-799, and FMC rates. The main thrust of this study is to determine whether there is any correlation between

MTIP training and the operational readiness of the Tomcat (F-14) and Hawkeye (E-2) aircraft communities stationed at Naval Air Station, Miramar, California.

This research is based on the data collected from the Flight Activity, Inventory and Readiness Report; the Individual Maintenance Action Record; and the Monthly MTIP Completion Rates from the Fighter Airborne Early Warning Wing, U.S. Pacific Fleet (FITAEWWINGPAC).

B. THESIS ORGANIZATION

Chapter II discusses the evaluation methods available to authors, and reviews and summarizes the previous literature reporting the performance measures used to evaluate the effectiveness of maintenance training. Examples are given of how various methods of measurement were performed.

Chapter III provides an in-depth background of the Naval Aviation Maintenance Training Program (MTIP). Policies, procedures, requirements, minimum standards, and assigned responsibilities of the MTIP training are discussed.

Chapter IV presents the data collected from the Equipment Condition Analysis Report and the MTIP Completion Rates. Only relevant information from this raw data should be extracted, compiled, and displayed in a logical format. Also included in this chapter are the analyses that describe the strength of the statistical relationships between the selected performance indicators and MTIP completion rates.

Finally, Chapter V contains conclusions and recommendations about the impact and effectiveness of MTIP training on the operational readiness of aviation squadrons.

II. BACKGROUND

A. INTRODUCTION

The purpose of aviation maintenance training is to prepare sailors to perform the technical tasks necessary to assure the availability and proper functioning of aircraft weapons systems and support equipment. Aviation maintenance training programs should be considered dynamic entities that slowly accomplish their purpose in meeting predesigned objectives. Without systematic evaluation, there is no feedback to provide the information necessary to improve the programs through the selection, adoption, and modification of new or existing instructional designs. It is important to use the most systematic procedures available that fit the particular setting being investigated, to control as many variables as possible, and to recognize the limitations of the design being used. This chapter examines the variables that can affect an evaluation and describes the various evaluation methodology available to researchers, following a review of previous studies.

B. FACTORS THAT AFFECT EVALUATION

The need for a systematic evaluation of the Maintenance Training Improvement Program (MTIP) implies a need for measurement techniques that clearly establish the relationship between training and performance on-the-job. In training settings that can be tightly controlled, evaluation can be straightforward. For example, on-site training in a manufacturing setting is conducive to evaluation. Conceivably, personnel could be tested on work skills before training (pretesting), training would be completed, and workers would be tested again after training (posttesting). In such a setting it is likely that job performance measures would be readily available and, therefore, posttest performance could be compared to pretest performance to evaluate the effectiveness of the training. Unfortunately, most real-world training occurs in settings where such tight control--and perfect evaluation--is not possible. Two areas that make training evaluation problematic are discussed here: (1) threats to internal validity, and (2) threats to external validity. Threats to validity can be controlled through selection of the appropriate experimental design, which is also discussed here.

1. Internal Validity

Internal validity refers to whether the training program makes a difference within the instructional setting. That is, if a test is given immediately after training, e.g., in the classroom, and scores are higher than they were on a test given immediately before training, can those differences be attributed to the training--did learning occur? Of course, the real concern is with transfer of learning to on-the-job performance, that is, did learning occur and also produce better performance? However, the issue of transfer of training cannot be dealt with unless internal validity has been established.

Variables other than instructional events that affect the results of training are threats to internal validity. Examples of som. of these variables have been described by Goldstein (1993):

a. History

This variable refers to specific events occurring between two measurements that could influence or provide alternative explanations for the results of a training evaluation. For example, with the outbreak of the Gulf War, a few squadrons were required to take the posttest without completing the entire training program in order to meet the new deployment schedule. This unplanned change may produce significant differences that have no relationship to the material presented in the original instructional program.

b. Maturation

This refers to both biological or psychological effects that vary with the passage of time (getting older or loss of interest in the program between two measurements) and affect performance for reasons unrelated to a training program.

c. Testing

A pretest may influence the results of the posttest. Simply becoming familiar with the types of questions on the pretest may enable a maintenance technician to concentrate on materials that may provide answers to the next test.

d. Instrumentation

Changes in grading standards, configuration changes with a new model/type of equipment, or even changing the evaluator can result in differences between two measurements that make it difficult to determine if learning occurred.

e. Selection of Participants

It can be difficult to determine the effects of training when participants bring differing amounts of knowledge to the learning situation that cannot be accounted for in the experimental design. For example, when only group performance can be used as the measure of training even though pretesting and posttesting for individuals are conducted (which is the case in the present research), differences could occur between the experience levels of different groups. However, this variable is best controlled by random selection of the entire population.

f. Interactions

Any of the variables discussed may interact to create a threat to internal validity. The likelihood of this occurring is increased when training is evaluated outside of a controlled, laboratory setting.

g. Rivalry between Participants

When an evaluation is made public or when two units are assigned to a particular condition, the special effort based on motivation may wipe out a true reflection of how each group would ordinarily perform.

2. External Validity

External validity deals with the ultimate concern of training: not only did learning occur, but can it be generalized to other groups and settings? Most relevant here is the issue of whether training is related to on-the-job performance. Threats to external validity, again discussed in Goldstein (1993) include the following:

a. Reactive Effect of Pretesting

As noted earlier, a pretest can sensitize individuals to information presented in training with the results of improved posttest scores. In research studies, where evaluation often takes place, pretesting may be used during the research--thereby enhancing the effects of experimental training--but not in the actual implementation of the training.

b. Interaction of Selection and Experimental Treatment

The characteristics of the group often determine the applicability of the findings for other purposes. The characteristics of maintenance technicians from one squadron may result in the training being more or less effective for them as compared to an another squadron.

c. Reactive Effects of Experimental Settings

Controlled environments with special setups and equipment, which may be used in evaluation research, can lead to changes in behavior that will not be present when training is implemented in a non-research environment.

3. Experimental Design

A variety of experimental designs are available to evaluate the effects of training. The ideal design is one that would produce "clean" results, having eliminated all threats to validity. With such an ideal model one could conclude with complete confidence that observed results were a function of the training. This ideal model would require the availability a group who receives training (experimental group), matched to a group for comparison that did not receive training (control group), and the opportunity for pretesting and posttesting with objective performance measures. In real-world settings, the use of the ideal experimental design is rarely possible. Therefore, the experimental design is tailored to accommodate the constraints of the training and/or on-the-job setting. These modified designs will control threats to validity of the findings differently. While not always perfect, many researchers have discussed the importance of doing partial evaluation instead of avoiding it because of the inherent difficulties (Peterson, 1978). Some of the traditionally used designs are discussed here.

a. The One-group Posttest Only Design

Trainees are exposed to the training program without a pretest and then are tested upon completion of training. Without the pretest baseline and a control group to compare it with, it is not possible to ascertain any change as a result of the training program. This design is quite limited, because findings cannot be generalized to other areas.

b. The One-group Pretest and Posttest Design

The participants are given a pretest before the training program, and a posttest upon completion of training. This design provides a measure of comparison between performance before and after the training program. Again, without a control group, it is difficult to establish whether the change is due to the training program. Internal validity variables such as history, maturation, testing effects, and changes in instrumentation are not well controlled.

c. Pretest and Posttest Control-group Design

The participants are chosen at random and assigned randomly to the experimental group or control group. Each group is given a pretest and posttest, but only the experimental group is provided with the training program. Many of the internal validity threats are controlled. Variables such as history, maturation, and pretesting affect both groups equally. Differential treatment of participants in both groups must still be controlled by the evaluator. Pretesting does sensitize and affect participants. To control this sensitization, a third group may be introduced without taking the pretest, which is the intent of the next design.

d. Solomon Four-group Design

This procedure is designed to consider external validity variables. This method adds two groups that are not pretested--one with training, one without training. If the participants are randomly assigned to the four groups, this design makes it possible to compare the effects of pretesting. A comparison of the posttest for group 4, which was not exposed to pretesting or training, to the pretest scores of groups 1 and 2 makes it possible to analyze the combined effects of maturation and history.

e. The Time-series Design

This method is similar to the one-group posttest design, except that a series of measurements are taken before and after training. If there are no appreciable changes through successive measurements, it is unlikely that any effects will occur due to maturation or testing. The major internal validity threat with this method is the history factor where events may change as environmental changes and historical occurrences are not controlled by this procedure. This design does not control most of the external validity threats. Therefore, it is necessary to be sensitive to factors that might make results difficult to generalize to other groups.

f. The Nonequivalent Control-group Design

This design is similar to the pretest and posttest control group design, except the participants are not assigned to the groups at random. This design utilizes groups already established such as class cohorts, where manipulating assignment to groups is not possible. If there is no alternative, this method is well worth using and is preferable to designs that do not have control groups such as the pretest and posttest group design. The more similar the two groups and their scores on the pretest, the more effective the control becomes in accounting for factors like history, pretesting, maturation, and instrumentation. This design is vulnerable to interactions between maturation, history, and testing because the participants were not randomly selected.

And there is always a chance that they differ on some critical variable.

4. Other Evaluation Models

While variants on experimental design models are traditionally used for evaluating training, there are other approaches that can be used.

a. Individual-difference Model

This method uses statistical methods to measure the relationship between training and actual job performance. The emphasis here is on demonstrating that performance in training will predict performance on the job. Typically, correlation coefficients are used to measure the relationships of interest. The problem, of course, is that correlations measure relation, not causation. A strong correlation in this situation means that people who do well in training do well on the job. The correlation does not say that the training program caused people to do well on the job. This concept is relevant to this thesis and will be discussed further in the discussion of the results.

b. Content-validity Model

This method relies on the assumption that judgements can be made about the adequacy of the design of the training program. If the needs assessment has been done correctly and has been used to determine the knowledge, skills, and abilities (KSAs) taught in the program, then the program is content valid. Effectively, the concept is that a good needs analysis automatically guarantees that the training is related to the KSAs needed from the job. The problem is that the method does not address whether the KSAs have been learned or, in fact, transferred to the job. Assuring content validity and performing correlational analyses would provide a more adequate means of evaluating training.

C. REVIEW OF PREVIOUS STUDIES

There has never been a study conducted to evaluate the Maintenance Training Improvement Program (MTIP). However, a few studies have examined operational readiness measures such as malfunction code A-799 no-defect rate, sortie completion rate, and elapsed maintenance time. These studies demonstrate some of the approaches that have been taken to evaluate training in real-world settings. Examples of these are summarized below:

1. Orlansky and String (1981), reviewed a group of seven studies across all military services. The evaluation method used in this review does not fit into any models described in this chapter. Basically, information was collected and found that non-faulty parts were removed in 4 to 43 percent of all corrective maintenance actions accounting for 9 to 32 percent of all maintenance man-hours. Non-faulty parts are those that were removed but found not to be defective when received for repair by the next level of maintenance activity. The

researchers concluded that these data offer strong evidence that maintenance technicians may conduct maintenance in an inappropriate and inefficient manner. The researchers offer no inference to identify the factors that may lead to inappropriate maintenance. However, training is considered a possible factor contributing to the high A-799 rate.

2. Horowitz and Angier (1985) found that the experience level, as indicated by the paygrades of the maintenance personnel, is the most consistent predictor of readiness. Using the number of Navy A-7 aircraft flights off a carrier in a quarter as a measure, a positive relation between paygrades and the number of sorties completed per quarter was observed. The researchers concluded that formal training and on-the-job experience/learning have an observable and meaningful impact on operational measures. However, the evaluation design used in this study again does not resemble any of the models described in this chapter. No pretest or posttest nor control group was employed in this study. Again, a relationship was measured--not causation--and the results could have been caused by variables such as history, maturation, or motivation. Without controlling these factors, ascertaining any change in the performance as a result of training is not possible.

3. Johnson, McConnell, and Murdock (1983), used data from the Air Force Consolidated Data System for F-16 aircraft and found that speed in accomplishing maintenance tasks was

related to the completion of formal school training provided by the Field Training Detachment (FTD). No pretest or posttest was conducted to measure the effects before and after the training program. Variables such as history and maturation were not positively controlled. However, control groups were used to evaluate the effects of formal training. Maintenance work centers with over 60 percent FTD-trained personnel were compared with work centers with less than 60 percent FTD-trained personnel. The data collected were limited to Work Unit Codes that are used to identify the system, subsystem, assembly and component, etc., on which the maintenance task is performed. Formal training had a greater effect on reducing the time needed to perform maintenance than did the number of maintenance actions performed by a worker. The study finds that work hours used to complete a task is a meaningful and useful productivity measure that is sensitive to differences in training backgrounds and methods.

As evidenced in real-world settings of these studies, there are no proven off-the-shelf methodologies for evaluating maintenance training programs where both internal and external threats can be tightly controlled. The primary goals of the Maintenance Training Improvement Program (MTIP) are to raise technical knowledge levels, to contribute to unit performance and to enhance and improve existing formal training. Without systematic evaluation, there is no feedback to provide information necessary to improve this program.

The next chapter examines the Maintenance Training Improvement Program in detail. Policies, procedures, requirements, minimum standards, and assigned responsibilities of the MTIP training are discussed. The methodology for this thesis study relative to the concepts discussed here are explained in Chapter IV.

III. MAINTENANCE TRAINING IMPROVEMENT PROGRAM

A. INTRODUCTION

The Assistant Chief of Naval Operations (Air Warfare), as program sponsor, provides the following overall program direction:

> The Maintenance Training Improvement Program (MTIP) is a training management system which shall be implemented throughout naval aviation (Chief of Naval Operations, OPNAV Instruction 4790.2E, June 1990).

Since the mid-80s, MTIP has become an integral part of the overall aviation maintenance training program. It is compatible with and supports the formal technical training programs in naval aviation. MTIP is designed to supplement formal training provided by the Naval Air Maintenance Training Group (NAMTD) and Fleet Readiness Aviation Maintenance Personnel (FRAMP). All personnel should receive formal training prior to, or upon assignment to, a maintenance production work center. In cases where formal training is not received, MTIP testing is the only assessment tool available to determine an individual's knowledge level. The primary goals are to raise technical knowledge levels, and to enhance and improve existing formal training.

The Maintenance Training Improvement Program (MTIP) is the primary method used to identify personnel training deficiencies at the organizational and intermediate maintenance levels. Through diagnostic testing procedures consisting of standardized question and answer banks from which computer generated tests are assembled, a qualitative assessment of individual technical knowledge can be made. The questions are designed to test knowledge of systems for each occupational specialty/rating required of a maintenance technician on the job. As deficiencies are identified, refresher or remedial training is conducted. Such assessments not only help to improve existing training materials and courses but also:

1. Establish the baseline knowledge level of an aviation community such as F-14 TOMCAT or E-2 HAWKEYE, or a particular squadron, work center, and/or an individual technician compared to his or her peers.

2. Concentrate training efforts where they are most needed, according to the established baseline.

3. Provide a training program tailored to individuals.

4. Correct specific systems knowledge deficiencies prior to extended deployment while dedicated training resources are available.

5. Provide a feedback loop across all phases of training, and interface with all echelons from the user through the functional wing (COMFITAEWWINGPACINST 1540.1J).

MTIP training primarily relies on static media such as printed technical manuals, workbooks, and slides. There is also some use of films and video, but the use of advanced instructional technologies (e.g., computer-based training) has not been incorporated. MTIP provides units with some flexibility to direct their own inservice training program and yet be able to compare the outcomes to established standards. However, as the rate at which a squadron operates increases, the program is often seen as administratively burdensome and secondary to operational requirements (Ledeboer, 1988). The operational tempo and commitments often become the driving factors for accomplishing the program.

MTIP is a training management system used to identify aviation personnel training deficiencies throughout the Navy, but the ultimate goal of MTIP is to improve the operational readiness of aviation squadrons. It is essential that training of aviation maintenance personnel be afforded the same level of attention as flight crew training. An effective MTIP requires high emphasis and dedicated effort at every level of command (COMFITAEWWINPACINST 1540.1J). This thesis examines whether there is any relationship between MTIP and the operational readiness of F-14 and E-2 squadrons within the Fighter Airborne Early Warning Wing, Pacific located at Naval Air Station, Miramar.

B. TEST REQUIREMENTS

All sea and shore duty aviation personnel (E-6 and below), including staff and administrative support services such as Quality Assurance Representatives (QAR), Aviation Supply/Storekeepers (AK), and Aviation Administrationman (AZ) who are assigned to an aviation maintenance department work center, are administered MTIP testing. QARs consist of senior, highly experienced technicians from various work centers (e.g., Power Plants, Avionics, etc.). They are hand-picked by their divisions, qualified by the Quality Assurance Division, and officially designated by the Maintenance Officer in accordance with the requirements set forth in OPNAVINST 4790.2E. They are detached from their work center and assigned to serve as staff members responsible to the Quality Assurance Division. All QARs are tested not only in the technical knowledge of their occupational specialty but also for skills in quality assurance administration. All E-5s and E-6s assigned to production work centers in supervisory positions are tested in their occupational specialty, as well as on Naval Aviation Maintenance Program (NAMP) supervisory knowledge. Tests on NAMP supervisory knowledge are not required of QARs, AKs, or AZs.

1. Sea Duty Personnel

For aviation squadrons deploying as part of a Carrier Air Wing Group (CVW), MTIP testing is scheduled by the parent functional wing Maintenance Training Team. There are two required tests for each complete training cycle (from completion of a deployment to the start of a next deployment), which varies in length in accordance with the Commander Naval Air Force United States Pacific Fleet (CNAP) deployment schedule and averages one to one and half years. The two required tests are discussed in the following paragraphs:

a. Post-deployment Test (CM)

Testing materials are sent by the functional wing Maintenance Training Team to the Carrier Air Wing Group (CAG) Maintenance Officer for administration of post-deployment testing by the squadron Assistant Maintenance Officer. Those personnel who will not take part in the next deployment are not required to take the CM tests. However, any prudent maintenance officer will undoubtedly strongly encourage all personnel to take the post-deployment test for the sake of providing continuous training until an individual is ready for transfer. CM tests may be completed up to forty-five days prior to completion of the deployment, but no later than thirty days after return from deployment (COMFITAEWWINGPACINST 1540.1J). Completing the post-deployment test early enables the packages to be graded, analyzed, where deficiencies are noted and compared, and presented to the Commanding Officer of each squadron at the earliest possible time. An aviation unit's turnaround (from completion of a deployment to the start of a next deployment) Maintenance Training Improvement Program could commence immediately upon receiving the results. The various MTIP reports provided initially by the Maintenance Training Team (MTT) help the squadron maintenance training officer or chief petty officer to manage the training program by tailoring each individual's needs in accordance with his(her) areas of deficiencies. Whenever an updated status of the training requirements is desired, MTIP reports may be requested via the Aviation Training Support System (ATSS) computer terminal located at each squadron.

b. Pre-deployment Test (CP)

CP tests must be completed no later than ninety days prior to a deployment. All personnel (E-6 and below) who are taking part in the deployment are administered a pre-deployment test.

2. Shore Duty Personnel

For those aviation maintenance personnel (E-6 and below) assigned to units that do not deploy as a part of a Carrier Air Wing Group on a regular basis (e.g., training commands such as VF-124 and VAW-110 squadrons which are responsible for training maintenance personnel for F-14 and E-2 aircraft respectively), MTIP testing is completed annually.

Those who have less than six months remaining on a tour need not be tested. But again, for the benefit of an individual's professional growth, especially if his or her next assignment will involve a similar type of aircraft, the squadron maintenance officer should continue to identify weaknesses and to improve technical knowledge and skill.

3. Newly Assigned Personnel

Newly assigned personnel (E-3 and below) who have not completed Fleet Readiness Aviation Maintenance Personnel (FRAMP) pipe-line training are tested within six months of reporting to a maintenance production work center. This time requirement is not applicable to personnel assigned Temporary Duty (TAD) as a barracks compartment cleaner or as a member of the First Lieutenant Division responsible for cleanliness of squadron spaces. Temporary Assigned Duty may last an average of three months or more depending on the shortages of junior personnel. Therefore, it is possible that these personnel will not become part of the Maintenance Training Improvement Program until nine or more months after checking into a squadron.

All other newly assigned personnel are tested within thirty days of assignment to a maintenance department work center. If an individual has completed FRAMP completion tests (CF) within 30 days of reporting to a work center, the test results may be used to satisfy the initial MTIP testing requirements.

C. TASK AREAS TO BE TESTED

The composition and number of work centers vary according to the type of aircraft an activity maintains and operates. For example, Radar Fire Control Technicians (AQ) and Aviation Ordnance Technicians (AO) are not needed in an E-2 squadron. Even though work centers such as Aviation Administration, Aviation Storekeepers, Quality Assurance, Power Plants, Airframes, Parachute Riggers, Environmental Control, Electronics, Electric, and Plane Captain/Trouble Shooters are common to both F-14 and E-2 squadrons, system knowledge and skills required of the respective technicians differ considerably from one aircraft to another. Therefore, MTIP tests and lesson guides are tailored accordingly to meet an activity's requirements. They are based on applicable technical manuals, work unit codes, the Naval Aviation Maintenance Program (OPNAVINST 4790.2E), and other instructions. All test questions and lesson guides have a valid reference or training source sailors can study.

Areas of knowledge required of a technician can be numerous. For example, an Airframe Technician is required to be familiar with task areas in the landing gear system, hydraulics system, aileron system, rudder system, brake system, and pneumatic system. Each task area for each occupational specialty is included in the MTIP test. An E-2 squadron alone consists of approximately 121 task areas to be tested and managed. Every task area must meet the minimum standard set forth by the functional wing Maintenance Training Team. Depending on the skill level, past training, and experience level at the time of MTIP testing, it is possible for a squadron to accumulate three to four hundred combined deficiencies relative to the minimum standards.

D. REFRESHER TRAINING REQUIREMENTS

1. Minimum Test Scores

MTIP remedial training is required for all test areas in which scores are less than the previous year's functional wing average or sixty-three percent (whichever is higher). Depending on the task area, the minimum cut-off average score may be set as high as seventy-five percent by the functional wing. Those individuals who do not meet the cut-off grades are considered deficient in those task areas. Refresher training is also available to those who have successfully attained scores above the minimum standard but wish to improve or maintain their knowledge of the latest information.

2. Types of Refresher Training

a. Scheduled Training

Formal MTIP refresher training is the primary method used to correct documented deficiencies. Subject Matter Experts (SME) and other highly experienced technicians from Fleet Readiness Aviation Maintenance Personnel (FRAMP), Naval Aviation Engineering Services Unit (NAESU), and Naval Air Maintenance Training Group (NAMTD) are designated as training instructors. Quarterly MTIP training classes are scheduled and published by the functional wing Maintenance Training Team. Quotas for training classes are assigned as requested by squadrons. Due to the large number of task areas to be covered, a particular training class may or may not be repeated within the same quarter. But over time, every task area will be covered as many times as possible to satisfy every squadron's needs.

Upon completion of refresher training, the MTT ensures retesting is conducted for each individual as soon as the class is completed. Additional refresher training is required if the minimum standard is not met.

b. In-house Training

MTIP lesson guides similar to those used by the designated instructors are available in computer disks and distributed to each squadron for conducting refresher training at their own convenience. Reviews and changes to these lesson guides are coordinated by the MTT. Subject matter experts from FRAMP, NAESU, NAMTD and the squadrons play a vital role in keeping these lesson guides accurate and current. Using these lesson guides, training can be conducted anywhere and anyplace that operational tempo permits, regardless of whether a squadron is on an aircraft carrier for work-ups or on a detachment to a remote training ground. Training quality with this method can be comparable or better than the formal refresher training at the home base if the subject matter experts from NAESU or the contractors accompany the squadron as a member of the detachment. Retesting can be administered on site or upon returning to the home base but tests can only be graded by the functional wing Maintenance Training Team. Testing materials are treated with the utmost security and confidentiality.

c. Integrated Weapons Systems Review (IWSR)

One other very useful and effective method of hands-on training, mostly applicable to the Electrical and Avionics ratings, is the Integrated Weapons System Review (IWSR). With squadron aircraft assigned strictly for maintenance training, maintenance technicians can proceed through the learning process with the help of subject matter experts from NAESU or the contractor. Due to the involvement of operational aircraft along with outside technical experts, IWSR requires tremendous planning and scheduling effort. Therefore, only the more experienced technicians are normally assigned to this type of training. Assigned aircraft and technicians involved in IWSR are not available for the day-to-day operational commitments of a squadron which may last as long as two to three weeks. IWSR is normally scheduled towards the latter part of a training cycle. IWSR may be considered the climax of turnaround (from completion of a deployment to the start of a next deployment) training effort, signaling the nearness of an upcoming extended deployment. The experience gained by these few assigned technicians during the IWSR is expected to be passed on to the rest of work centers.

3. MTIP Completion Rates

Pre-deployment tests for sea duty personnel and annual tests for shore duty personnel mark the end of a training cycle and freeze the percentage score of an aviation unit. The MTIP completion rate is the number of deficiencies corrected divided by the total number of CM and CF deficiencies times 100. For example, if a squadron completes 293 of the combined CM and CF total of 470 deficiencies during a turnaround training cycle, it is said to have attained a 62 percent MTIP completion rate. A minimum of seventy-five percent of deficiencies noted in the post-deployment (CM) and FRAMP completion (CF) tests is to be corrected using scheduled training and/or in-house training (both described earlier in this chapter) during the turnaround training cycle.

4. MTIP On-the-Job Training (OJT)

On-the-Job (OJT) is the practical instruction of personnel in the performance of maintenance tasks. Under the supervision of qualified personnel, the trainee learns to complete tasks using an appropriate maintenance manual. Experienced personnel are used to instruct, demonstrate and impart their skills to the less experienced. Trainees learn by observing job performance and gain experience by participating in the work effort. OJT syllabi are prepared to complement MTIP task areas. Attainment of a task area score at or above the cut-off on either the MTIP test or refresher training test is a prerequisite to final MTIP OJT qualification in a task area. When an individual completes MTIP OJT qualification, he(she) is considered fully qualified to perform the task indicated. This qualification will remain in force until:

1. A score, on a subsequent CM MTIP test, indicates a requirement for refresher training on those task areas with scores below the cut-off.

2. Transfer to an another unit.

E. MTIP TRAINING REPORTS

Aviation Training Support System (ATSS) is a Manpower, Personnel and Training (MPT) Automatic Data Processing (ADP) system that provides principal support for FRAMP, NAMTD, Aircraft Intermediate Maintenance Department, and operational fleet squadrons during the turnaround training cycle (COMFITAEWWINGPACINST 4500.3).

ATSS is used for MTIP data collection, testing and reporting. Access to the MTIP data base is controlled by user identification codes and passwords. Currently, ATSS has seventeen separate reports (see Appendix A) available under the Maintenance Training Improvement Program. Most of these reports, especially those involving test question data, are not available to an aviation unit. The most commonly used reports directly accessible by a squadron are:

M01 MTIP Personnel Training Report

M02 MTIP Work Center/System Training

M05 MTIP Squadron/Work Center CDP Report

M10 MTIP Squadron Training Requirements Reports

M21 Squadron Turnaround Training Progress Report

With these reports, a squadron training officer or chief petty officer has all the information needed to concentrate training effort where it is most needed. He or she has the option to go beyond the MTIP refresher training by sending those individuals back to formal schools offered by other training commands such as NAMTD.

F. SUMMARY

MTIP has become an integral part of the overall aviation maintenance training program in the Navy. It is a training management system used to identify training deficiencies at the various levels, ranging from an individual to the aviation community as a whole. Through diagnostic testing procedures, a qualitative assessment of individual technical knowledge is made for all aviation maintenance personnel. Based on this information, the training program is tailored to an individual's needs and concentrates efforts where they are most needed. The completion rates for each aviation squadron are used to measure the overall effectiveness of Maintenance Training Improvement Program. However, the effects of a training program should reflect on unit performance and operational readiness, which provide the final measure of effectiveness and represent the end products of the maintenance training system.

The next chapter examines the effects of MTIP on F-14 and E-2 squadrons at Naval Air Station, Miramar, California. Using the MTIP completion rates and information collected under the Naval Aviation Logistics Data Analysis (NALDA), analyses are conducted on the relationships between training and operational readiness.

IV. METHOD AND RESULTS

A. INTRODUCTION

This chapter discusses the method, participants, materials, procedures, and limitations of this study. It also presents the data that are used in analyzing relationships between Maintenance Training Improvement Program (MTIP) completion rate and operational readiness measures such as Full Mission Capable (FMC) rate, number of no-defect (A-799) maintenance actions, and Direct Maintenance Manhours per Flight Hour (DMMH/FH).

B. METHOD

Training is the systematic acquisition of skills, rules, concepts, or attitudes that result in improved performance in another environment (Goldstein, 1993). In order to capture these two environments, a measure comparing performance before training and an assessment of on-the-job performance following training are needed to evaluate the effects of the Maintenance Training Improvement Program.

As discussed in Chapter II, a variety of experimental designs are available and of course, the ideal model is one that would produce "clean" results, having eliminated all threats to validity. But most real-world training occurs in settings where perfect evaluation with an ideal model is rarely possible. Due to the inherent nature of military service, with the necessity to undertake operations on short-term notice, an aviation squadron may be called into action thousands of miles away from home base for an extended period of time. It is not practical to collect data under test conditions that need to be designed and set up each time information is needed. It is logical to seek a methodology based on practicality and on existing available information to track long-term trends in unit performance and combat readiness.

Therefore, the experimental design needs to be tailored to accommodate the constraints of the training and/or on-the-job setting. A desirable design would differentially control as many threats to internal and external validity as possible, and minimize constraints imposed by the environment and the influences of the multitude of organizational variables. While not perfect, the data collected under these conditions makes it possible to avoid a useless evaluation. As Peterson (1978) suggests,

> It is better to approximate evaluation than neglect it altogether due to its difficulties. For example, measuring learning not only at the end of the course, but sometime later is better than nothing just because you can't get measures of behaviors or results.

Based on the concepts discussed in Chapter II, and to accommodate a real-world, on-the-job setting as explained above, the locally available MTIP records combined with the Navy's existing maintenance data base from Naval Aviation Logistics Data Analysis (NALDA) were selected for this study. These data provide a practical approach to measurement, and also reflect the ultimate outcome that one would expect from a training program.

MTIP is conducive to the one-group pretest/posttest evaluation method. All maintenance personnel (like an experimental group) assigned to each squadron are given a pretest (post-deployment test) to establish the baseline of training deficiencies, then presented with the training program, and finally given a posttest (pre-deployment test). The MTIP completion rate (Chapter III, section D, subsection 3) represents the final effort of the training program in terms of percentage completed during the allotted time period. Appendix B lists all squadrons' completion rates for this study. Newly assigned personnel and those scheduled to be transferred before the next deployment are automatically excluded from the MTIP completion rate calculation by the Aviation Training Support System (ATSS) computer data management program. This method provides a measure of comparison between before and after training for the same group of personnel. Unfortunately, without permission from the highest level of authority in the Navy, and also for obvious practical reasons, control groups are not feasible for the purpose of this evaluation process. Therefore, it is difficult, without a control group, to ascertain that the training program is the prime factor determining any differences that occur between measurements.

On the other hand, the Naval Aviation Logistics Data Analysis (NALDA) System provides a data base for fleet maintenance and operations. It provides information on unit performance and operational readiness of an aviation unit. Full Mission Capable (FMC) rate, number of no-defect (A-799) maintenance actions, and Direct Maintenance Manhours per Flight Hour (DMMH/FH) were extracted from the NALDA system; they are listed in Appendices C and D. The FMC rate is a percentage figure based on the monthly total available equipment in-service hours that all systems are fully functional to perform all missions designed for an aircraft. A-799 actions are the number of maintenance actions involving components removed by the Organizational Maintenance Level ("O" Level) technicians as defective that are found to operate properly when tested later. DMMH/FH is the average amount of direct maintenance manhours required to support each flight hour. These operational measures reflect what should be learned as a result of a training program and answers the question of improved performance in another environment, on-the-job-setting. As noted by other researchers,

> The effects of training on unit performance and operational readiness provide the final measure of training effectiveness and represent the end products of the maintenance training system (Gibson and Orlansky, 1986, pp.48).

One advantage to using information from the NALDA system is that it provides an objective measure of real maintenance performance. Since data bank information is collected routinely and unobtrusively, it represents actual performance as opposed to data collected under test conditions that may be subject to the "Hawthorne Effect" (Gibson and Orlansky, 1986, pp.26).

However, the disadvantage is that the service's maintenance data was not specifically designed for training purposes. To be useful for evaluating the effect of training on an individual, it is necessary to be able to clearly relate the maintenance data to the specific system, work center, and the performing technician. The NALDA information does not identify individual(s) who was(were) actually involved in the performance of a maintenance task. Therefore, the objective measures of performance collected by this method only reflect the group as a whole.

Correlation analyses are conducted between the results of the MTIP completion rates and the selected performance measures from the NALDA data. It is reasonable to believe that well-trained personnel perform better on their jobs than less-well-trained personnel. It is assumed here that higher MTIP completion rates are related to better-trained personnel. If this is so, the effects of better training should be observable in the selected NALDA operational measures.

1. Participants

During the planning phase of this study, the author examined the types of aircraft that are deployable aboard an aircraft carrier. The west coast carrier deployable aircraft are home-based at several Naval Air Stations (NASs) in the State of California, including NAS Lemoore, NAS North Island and NAS Miramar, and at NAS Whidbey Island located in the State of Washington. Preliminary information was requested from the Maintenance Training Improvement Program Offices and the Data Analysts of the Pacific Fleet Light Attack Wing (LATWINGPAC) at NAS Lemoore, Anti-Submarine Warfare Wing (ASWWINGPAC) at NAS North Island, and Fighter Airborne Early Warning Wing (FITAEWWINGPAC) at NAS Miramar. The author understands the extra workload that such requests place on personnel at these units. Thus, it is not surprising that cooperation was sporadic. However, the MTIP Office and the Data Analyst from the FITAEWWINGPAC have been extremely cooperative and helpful. Therefore, F-14 (Tomcat) and E-2 (Hawkeye) squadrons under the Fighter Airborne Early Wing, Pacific Fleet at Naval Station Miramar were selected as the subjects of this thesis.

Once the types of aircraft were selected, the emphasis was placed on the sea-going squadrons to be consistent with the types of operational cycles involved (e.g., post-deployment, turnaround training, and deployment). Ten F-14 squadrons and six E-2 squadrons are considered to be sea-going units.

However, two F-14 squadrons and one E-2 squadron are currently assigned to USS Independence, homeported at Naval Station Yokosuka, Japan. These three squadrons are excluded from this study because of their unique operational tempo, which is quite different from the rest of the squadrons. Therefore, the total number of squadrons involved in this study is thirteen.

An average of 180 and 110 enlisted maintenance technicians are respectively assigned to each F-14 and E-2 squadron. After subtracting fifteen percent (a conservatively high estimate) of E-7 and above enlisted personnel from each squadron, the number of E-6 and below maintenance technicians is estimated to be around seventeen hundred.

Since all maintenance personnel (E-6 and below) are required to be tested under the Maintenance Training Improvement Program, the age bracket of these personnel ranges from 19 years old to the early 30s. There are no females currently assigned to sea-going squadrons deployable aboard aircraft carriers in the Navy. With recent changes in the political climate, this will certainly change in the near future.

Due to the method of data collection from the two centralized sources, none of these maintenance personnel, squadrons, nor the FITAEWWINGPAC staffs are aware of this experiment. This is done to hopefully control some of the internal and external variables which may influence the evaluation process.

2. Materials Used

a. Source of Data

The data for this study came from two of the Navy's data banks: Aviation Training Support System (ATSS) and Naval Aviation Logistics Data Analysis (NALDA) System. Maintenance Training Improvement Program records are managed by the ATSS located at Naval Air Station Miramar. Operational readiness data are obtained from the NALDA System, Patuxent River, Maryland via a computer terminal with the assistance of the FITAEWWINGPAC Data Analyst at NAS Miramar.

Due to data processing and storage limitations of ATSS, most squadron MTIP records are only kept to cover a period of a couple of years. Therefore, the historical files including the messages issued monthly by the FITAEWWINGPAC MTIP Office during the period of January 1989 to December 1992 are used as the source of the MTIP completion rates. As a result of this limitation, operational data from NALDA has also been selected to match the available MTIP records covering the same period.

The total number of pages of NALDA information obtained for this study is estimated to be about 1200 pages of full size computer printouts. Even with the assistance of a senior, experienced data analyst, the NALDA data took more than two months to collect. First of all, this is partly due to the tremendous amount of time required to get connected with the NALDA system. The data has to be requested by each squadron, and by each month for which it is needed, in the format desired and it has to be printed via telephone line with computer hook-up to the source. Secondly, the data analyst had to do all of this on a voluntary basis and very often on his own time.

b. Hardware and Software

A standard IBM PS/2 286-based micro-computer, model 60 with one megabyte of RAM and Disk Operating System (DOS) Version 5.0 served as the work station for this study. This system is probably considered antiquated compared to what is available on the market today. However, for conducting a routine statistical analysis, this system serves the purpose more than adequately.

The Lotus 1-2-3 (DOS Version 2.2) spreadsheet software program was used to discriminate, sort, and compile the 1200 pages of raw data to a form relevant for the periods under consideration. These files were used as inputs to a second software program, Statgraphics (DOS Version 6.0), for the correlation analysis. Lastly, WordPerfect (DOS Version 5.0) was used to document the entire process.

C. PROCEDURE

Now that the methodology, participants, and software/hardware have been discussed in detail, the steps in the execution of this analysis can be summarized as follows:

1. Collect MTIP completion rates and NALDA operational measures for each squadron.

2. To ensure comparability, the MTIP data has to be compiled in parallel with each squadron's turnaround training cycle (from post-deployment test to pre-deployment test) and the NALDA data has to cover the time period following the pre-deployment test to the next post-deployment test. The assumption is that during deployment (including a month or two before and after training) each squadron is provided with maximum support from up and down the chain of command. If absolutely necessary, the support will come in the form of temporarily sacrificing or limiting the operational capabilities of other similar commands not scheduled for deployment. Therefore, squadrons on deployment will most likely be as closely comparable as possible. In this manner the effects of training are measured with operational readiness under similar conditions.

3. MTIP completion rates represent training efficiency of each squadron as a whole with one number representing the total effort of the entire turnaround training. However, operational readiness figures, which are also group measures for each squadron, are collected on a monthly basis throughout

the deployment. Therefore, the operational readiness data needs to be averaged out so that it may be compared with the MTIP data. To ease the management of these data, Lotus 1-2-3 was used to arrange/rearrange, compile, and calculate the information required.

4. Import the compiled data from Lotus 1-2-3 to the Statgraphics program and conduct correlation analyses.

D. LIMITATIONS

1. Available Data

As mentioned earlier in this chapter, non-availability of the MTIP data over an extended period of time limits this study to a period of four years. Considering that most of the MTIP offices and the Aviation Training Support System (ATSS) retain information for only a couple of years, it is fortunate to be able to obtain the data covering the period from Jan 1989 to Dec 1992. This amount of data would seem sufficient to conduct an assessment of the Maintenance Training Improvement Program (MTIP).

However, squadrons deploy at different times during that four years. Some squadrons have a much longer turnaround training cycle than others, due to the transition to a newer model/type of aircraft or major configuration changes to the existing ones. A few squadrons are permanently stationed in Japan with different operating cycles than those in the continental United States. Some were in the middle of a deployment when the December 1992 data were collected. For these various reasons, on an average, each squadron has only one complete set of MTIP and NALDA data usable for this study.

2. Internal and External Validity

Due to the four-year period of time involved, specific events other than training occurring between sequential measurements were not subject to control. Biological or psychological effects that systematically vary with the passage of time as participants become older, fatigued, or more or less interested in the job between measurements were also not subject to control.

Influence of the pretest on the scores of the posttest and the reactive effects of the pre-deployment test which can lead to increased sensitivity to the instructional procedure were negligible because of the many months in between each test (6 to 8 months for post-deployment test and 12 to 18 months for pre-deployment test).

Rivalry between squadrons does exist. Sister squadrons that have the same deployment schedule under the same Air Wing often put up extra efforts to outperform the other. The MTIP office makes unannounced visits to those squadrons that are either doing too well or not too well to substantiate the reasons behind the success or failure. Self-serving, innovative ways of improving the MTIP completion rate is thus kept to a minimum. It is impossible to consistently manipulate completion rates or operational readiness measures.

Influences of the interactions between variables upon an evaluation are more difficult to understand and control. It is not clear as to how, and in what ways, such interactions affected this evaluation.

Other variables (see Chapter II for an explanation of these threats) such as instrumentation, differential selection of participants, and reactive effects of experimental settings are well under control. The Maintenance Training Improvement Program (MTIP) is mandatory for all E-6s and below. Each squadron operates under the same policy and guidance set forth by the highest level of the chain of command with the MTIP office serving as the monitoring activity. Squadrons going through major configuration or model changes are retested by the MTIP office based on the new information and are selectively excluded from this study.

E. RESULTS

Based on the consolidated data collected from the eight F-14 and five E-2 squadrons, this section provides the correlation analyses between the MTIP completion rates and the selected operational measures. The procedure generates a matrix of correlation coefficients for the observed values, and provides a preliminary view of the relationships among variables. The strength of the relationship between variables are evaluated using the Pearson Product Moment Correlation Coefficient. The coefficient values fall between -1 and +1. A positive correlation indicates that the variables vary in the same direction while a negative correlation indicates that the variables vary in the opposite direction. Statistically independent variables have an expected correlation of zero.

Tables 1 and 2 provide a synopses of the F-14 and E-2 aircraft community consolidated data, respectively, collected by each squadron on the MTIP completion rate, Full Mission Capable (FMC) rate, number of no-defect maintenance (A-799) actions, and Direct Maintenance Manhours per Flight Hour (DMMH/FH). In order not to disclose the name of each aviation unit, numbers are used to represent squadrons.

TABLE 1 F-14 CONSOLIDATED DATA

Squadron No.	MTIP Completion Rate (Percent)	Full Mission Capable Rate (Percent)	Number of A-799 Actions	Direct Maint. Manhours per Flt Hr (DMMH/FH)
1	57	56	69	36
2	75	62	61	45
3	73	61	64	58
4	75	63	63	38
5	31	33	58	52
6	65	36	50	56
7	50	43	52	29
8	62	35	43	92

Note: Detailed F-14 squadrons month-by-month operational figures can be found in Appendix C.

Source: Compiled from the MTIP Office historical files and NALDA data.

TABLE 2 E-2 CONSOLIDATED DATA

Squadron No.	MTIP Completion Rate (Percent)	Full Mission Capable Rate (Percent)	Number of A-799 Actions	Direct Maint. Manhours per Flt Hr (DMMH/FH)
1	37	30	46	26
2	66	60	34	24
3	41	67	42	22
4	72	57	16	23
5	90	68	21	24

Note: Detailed E-2 squadrons month-by-month operational figures can be found in Appendix D.

Source: Compiled from the MTIP Office historical files and NALDA data.

Table 3 provides a general overview of the intercorrelation statistics obtained, based on the procedure discussed in this chapter.

TABLE 3 INTERCORRELATION MATRIX

	MTIP	FMC	A-799	DMMH/FH
MTIP	*	0.61	-0.26	-0.02
FMC	0.61	*	-0.15	-0.45
A-799	-0.26	-0.15	*	0.36
DMMH/FH	-0.02	-0.45	0.36	*

Notes:
- MTIP Maintenance Training Improvement Program
- FMC Full Mission Capable
- A-799 Number of no-defect maintenance actions
- DMMH/FH Direct Maintenance Manhours/Flight Hour

1. Relationship of MTIP to FMC

Correlation between the Maintenance Training Improvement Program (MTIP) completion rate and the Full Mission Capable (FMC) rate shows that there is a moderate positive relationship between the two variables. As reflected in Table 3, the correlation coefficient is 0.61. The probability of a relationship this strong occurring by chance is 0.03 as determined by a t-test. In other words, the Full Mission Capable rate is positively associated with the MTIP completion rate. As the MTIP completion rate increases, the FMC rate also tends to increase in the same direction. However, this does not mean that there is a causal relationship between the two variables. We can only infer that the two variables have a moderate tendency to increase or decrease simultaneously.

2. Relationship of MTIP to A-799

Correlation between the Maintenance Training Improvement Program (MTIP) and the number of no-defect (A-799) maintenance actions produces a weak negative relationship. The MTIP completion rate and the number of A-799 maintenance actions have a correlation coefficient of -0.26 (see Table 3). The correlation is statistically insignificant. The probability of a relationship occurring by chance between these two variables is about 0.39. A negative correlation coefficient suggests that the variables tend to increase or decrease in the opposite directions simultaneously. However, a negative correlation between the MTIP completion rate and the number of no-defect maintenance actions is expected. Non-faulty parts are those that were removed but found not to be defective when tested later. Previous research does offer some evidence that maintenance technicians may conduct maintenance in a more appropriate and efficient manner as maintenance technicians learn through a training program and become more knowledgeable. Thus, the results found here are in the expected direction but not strong enough to be conclusive.

3. Relationship of MTIP to DMMH/FH

Even though it is reasonable to believe that with more training the time required to complete a maintenance action will be reduced, in this comparison, there does not appear to be any relationship between the MTIP completion rate and the Direct Maintenance Manhours per Flight Hour (DMMH/FH). The MTIP completion rate and the DMMH/FH have a negative correlation coefficient of -0.02. The probability of a relationship occurring by chance between these two variables is about 0.94. In other words, MTIP and Direct Maintenance Manhours per Flight Hour are statistically independent with a correl ion coefficient of nearly zero.

As reflected in Table 3, the correlation between the Direct Maintenance Manhours per Flight Hour (DMMH/FH) and the number of A-799 maintenance actions provides positive but not statistically significant evidence that as the number of inappropriate or inefficient maintenance practice increases, the Direct Maintenance Manhours per Flight Hour also increases in the same direction. The correlation coefficient is 0.36 and the probability of a relationship this strong occurring by chance between these two variables is about 0.23.

The correlation between the DMMH/FH and the Full Mission Capable (FMC) rate produces a moderately negative relationship. As expected, when the DMMH/FH decreases, the FMC rate improves. The correlation coefficient between the DMMH/FH and the FMC rate is -0.45. And, the probability of a relationship this strong occurring by chance between these two variables is at about 0.12.

Therefore, as seen in this section, the Direct Maintenance Manhours per Flight Hour could possibly be indirectly related to the MTIP completion rate through a third variable such as the number of A-799 no-defect maintenance actions or the FMC rate. The relationships between the MTIP completion rate, the FMC rate, the number of no-defect maintenance actions and the DMMH/FH are summarized graphically in Figure 1.

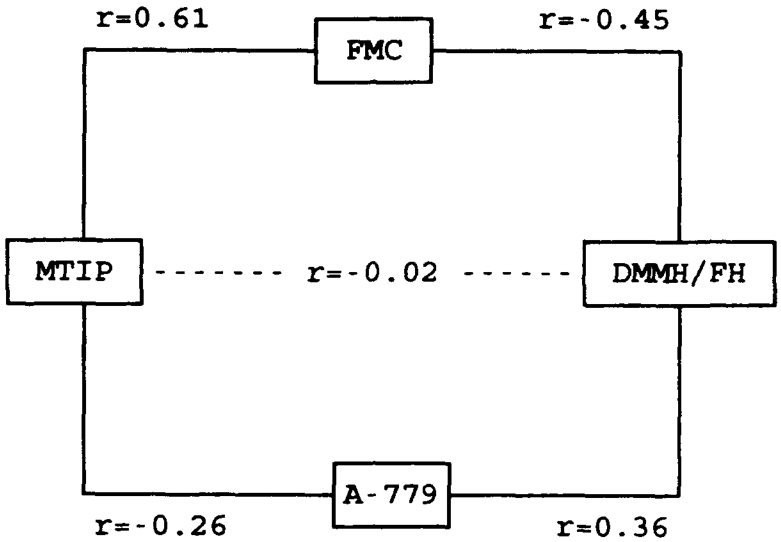

Figure 1. Intercorrelation Diagram

V. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

> Training is defined as the systematic acquisition of skills, rules, concepts, or attitudes that result in improved performance in another environment (Goldstein, 1993).

The purpose of the Maintenance Training Improvement Program is, therefore, to prepare sailors from the training environment to perform the technical tasks necessary in the real-world environment to assure the availability and proper functioning of aircraft weapons systems. The ultimate goal is to improve unit performance in terms of operational readiness. Without systematic evaluation, there is no feedback to provide information necessary to enhance and improve this training program.

Within the context of the limitations discussed earlier, the results of this thesis have provided empirical support for the idea that aviation maintenance training under the MTIP management system may have an impact on unit performance. The MTIP completion rate does show a tendency to increase or decrease simultaneously with one of the most important operational readiness measures--the FMC rate. The MTIP completion rate is a moderate predictor of the Full Mission

Capable rate; as more training is accomplished, the FMC rate tends to improve in the positive direction.

The MTIP has also been shown to have a negative relationship with the total number of no-defect maintenance actions performed by the maintenance technicians. Well-trained maintenance technicians are less likely to conduct maintenance in an inappropriate and inefficient manner. Therefore, fewer non-faulty parts will be removed and found to be operational later.

The MTIP completion rate appears to have no correlation with the Direct Maintenance Manhours per Flight Hour (DMMH/FH). However, as reflected in Table 3 and Figure 1 of Chapter IV, the MTIP completion rate is moderately and positively correlated to the FMC rate, and only weakly and negatively correlated to the A-799 actions. But at the same time, the DMMH/FH reveals that it is also moderately correlated to the A-799 actions and the FMC rates. Therefore, it is possible that the MTIP completion rate is somehow indirectly related to the DMMH/FH through a third variable such as the number of A-799 maintenance actions or the FMC rate. This is an area that could be explored further.

In interpreting the results of the research conducted for this thesis, using correlation analyses, some insight has been gained in explaining the question raised in the introductory chapter on whether the effects of training are observable in operational indicators.

B. RECOMMENDATIONS

This thesis has just touched the surface of evaluating the Maintenance Training Improvement Program and has disclosed several areas where there is room for more in-depth follow-up research. Hopefully, this paper will serve as the catalyst to ultimately enhance and improve the aviation training program under the MTIP management system.

Until now, the effectiveness of MTIP training has been evaluated primarily by end-of-course tests with the MTIP completion rate as the final group measure. Unless we have credible information about how well technicians perform after training in the real-world-setting, we do not know very much about whether the course provided the information needed to perform well on the job. This thesis has introduced some of the available operational measures to link training with operations. However, to better evaluate MTIP, operational measures should be directly traceable to an individual instead of a group. Modifications to the existing NALDA data base may be required. Use of local historical files is another option to trace an individual's training and his/her on-the-job performance. Measures other than the MTIP completion rate, such as job-sample tests and on-equipment performance tests, also need to be explored.

As observed in this study, collection and processing of the required data can be extremely time consuming. With some training and proper software packages, the Data Analysts and the Wing Training Officers could systematically collect the necessary data on a continual basis. They could also perform simple analyses on their own to draw inferences, revealing the possible weaknesses and strengths of a training program, or make these data available for further study by others like students at the Naval Postgraduate School.

It is recommended that the Aviation Training Support System (ATSS) database storage capacity and the local MTIP Office files be expanded to retain historical files over a longer period of time. It will be extremely useful to be able to track training performance over several complete cycles of training and deployment.

It is not clear at this point why the MTIP completion rate and the Direct Maintenance Manhours per Flight Hour did not produce the expected correlation. On one hand, the result may be a factor of the particular data captured here and not generalizable to other periods of time or other squadrons. On the other hand, if the data reflect weakness in the training, this is an important issue. Another possibility is that the zero correlation is a consequence of mixing data for two different aircraft types. Further research should be conducted to explore this finding.

Another research area that should be explored is the correspondence between the objectives of MTIP and actual job performance. Is there 100 percent correspondence between what is taught and what is expected on the job? Until this analysis is conducted, further evaluation may be meaningless.

In view of the results of this thesis in empirically linking the west coast F-14 and E-2 aircraft community Maintenance Training Improvement Program (MTIP) completion rates with the operational readiness measures such as the Full Mission Capable (FMC) rates and the number of no-defect (A-799) maintenance actions, the next logical step would be to conduct a study involving all types of aircraft in the Navy. Other exploratory studies will add information that can be used to ultimately determine the training effectiveness of MTIP. Resources allocated to MTIP and personnel safety make adequate evaluation critical.

APPENDIX A

AVAILABLE MTIP REPORTS

Report Number	Title
M01	MTIP Personal Training Report
M02	MTIP Work Center/ System Training
M03	MTIP Class Status
M04	MTIP Course Summary Report
M05	MTIP Squadron/Work Center/CDP Report
M06	MTIP Wing Test Area Report by Work Center/System
M07	MTIP Squadron Test Area Report by Work Center/System
M08	MTIP Wing Work Center/System Report by Squadron
M09	MTIP Wing Test Area Report by Squadron
M10	MTIP Squadron Training Requirements Reports
M11	MTIP Top Wing System Training Requirements
M13	MTIP Gradebook Random Report
M15	MTIP Test Item Data Random Review
M17	MTIP Work Center/System Report
M18	MTIP Post/Pre-Cruise Training Progress Report
M19	Functional Wing Refresher Training Progress
M21	Squadron Turnaround Training Progress Report

APPENDIX B

MTIP COMPLETION RATES

F-14 Squadrons	MTIP RATES (%)
1	57
2	75
3	73
4	75
5	31
6	65
7	50
8	62

E-2 Squadrons	MTIP RATES (%)
1	37
2	66
3	41
4	72
5	90

APPENDIX C

F-14 OPERATIONAL DATA

Squadron No.1

DATE	%FMC	A-799	DMMH/FH
1990&91			
OCT	38	59	28
NOV	NA	76	NA
DEC	45	86	42
JAN	64	115	21
FEB	61	80	18
MAR	66	77	24
APR	67	73	36
MAY	60	43	48
JUN	47	9	73
Avg	56	69	36

Squadron No.2

DATE	%FMC	A-799	DMMH/FH
1991			
JAN	50	85	22
FEB	62	74	20
MAR	63	79	41
APR	80	66	42
MAY	63	43	50
JUN	53	17	93
Avg	62	61	45

Squadron No.3

DATE	%FMC	A-799	DMMH/FH
1990			
FEB	60	23	73
MAR	NA	42	NA
APR	47	64	31
MAY	30	59	51
JUN	52	75	57
JUL	73	64	48
AUG	77	98	63
SEP	62	102	51
OCT	59	96	59
NOV	69	49	86
DEC	84	30	59
Avg	61	64	58

Squadron No.4

DATE	%FMC	A-799	DMMH/FH
1990&91			
DEC	53	37	26
JAN	52	62	36
FEB	56	56	41
MAR	67	107	27
APR	66	81	35
MAY	59	33	25
JUN	65	NA	26
JUL	76	NA	36
AUG	86	NA	82
SEP	49	NA	44
Avg	63	63	38

Squadron No.5

DATE	%FMC	A-799	DMMH/FH
1992			
MAY	57	NA	49
JUN	62	NA	30
JUL	57	NA	35
AUG	54	NA	49
SEP	42	NA	99
OCT	42	NA	53
NOV	65	NA	79
DEC	57	NA	41
Avg	55	NA	54

Note: Squadron No.5 is assigned to USS Independence.

Squadron No.6

DATE	%FMC	A-799	DMMH/FH
1989&1990			
NOV	44	52	75
DEC	52	19	60
JAN	38	62	98
FEB	26	91	33
MAR	34	73	23
APR	24	54	33
MAY	10	65	44
JUN	NA	46	NA
Avg	33	58	52

Squadron No.7

DATE	%FMC	A-799	DMMH/FH
1991			
MAR	15	70	48
APR	29	51	47
MAY	44	49	27
JUN	50	46	68
JUL	29	85	63
AUG	27	72	43
SEP	32	59	40
OCT	46	43	51
NOV	61	18	62
DEC	23	8	116
Avg	36	50	56

Squadron No.8

DATE	%FMC	A-799	DMMH/FH
1990			
FEB	50	57	40
MAR	100	56	44
APR	33	54	44
MAY	61	109	36
JUN	31	56	49
JUL	29	44	47
AUG	34	21	46
SEP	50	40	44
OCT	68	50	35
NOV	75	63	55
DEC	88	37	40
Avg	56	587	43

Note: Squadron No.8 is assigned to USS Independence.

Squadron No.9

DATE	%FMC	A-799	DMMH/FH
1990&91			
DEC	23	28	31
JAN	26	68	29
FEB	26	35	49
MAR	54	61	24
APR	54	66	22
MAY	47	61	23
JUN	58	89	27
JUL	35	57	29
AUG	72	25	33
SEP	33	30	26
Avg	43	52	29

Squadron No.10

DATE	%FMC	A-799	DMMH/FH
1991			
MAR	44	64	47
APR	25	63	46
MAY	36	42	35
JUN	44	43	58
JUL	43	73	70
AUG	18	50	60
SEP	24	39	49
OCT	37	29	85
NOV	55	19	91
DEC	25	8	377
Avg	35	43	92

APPENDIX D

E-2 OPERATIONAL DATA

Squadron No.1

DATE	%FMC	A-799	DMMH/FH
1991			
JAN	40	51	19
FEB	29	26	29
MAR	37	69	18
APR	20	55	24
MAY	31	68	30
JUN	NA	83	NA
JUL	NA	33	NA
AUG	35	19	21
SEP	18	6	38
Avg	30	46	26

Squadron No.2

DATE	%FMC	A-799	DMMH/FH
1990			
FEB	42	22	38
MAR	100	NA	26
APR	46	44	25
MAY	53	24	18
JUN	53	21	26
JUL	NA	48	NA
AUG	44	44	24
SEP	NA	62	NA
OCT	NA	34	NA
NOV	66	24	19
DEC	73	17	16
Avg	60	34	24

Squadron No.3

DATE	%FMC	A-799	DMMH/FH
1989&90			
NOV	82	19	24
DEC	62	29	29
JAN	75	36	25
FEB	72	49	24
MAR	71	67	15
APR	48	39	15
MAY	53	55	20
JUN	75	42	25
Avg	67	42	22

Squadron No.4

DATE	%FMC	A-799	DMMH/FH
1990&91			
DEC	75	42	35
JAN	22	19	71
FEB	32	57	33
MAR	44	32	18
APR	38	31	23
MAY	57	39	59
JUN	55	43	21
JUL	75	38	24
AUG	77	37	19
SEP	73	37	25
OCT	99	7	108
NOV	43	24	63
DEC	72	10	23
Avg	59	416	40

Note: Squadron No.4 is assigned to USS Independence.

Squadron No.5

DATE	%FMC	A-799	DMMH/FH
1990&91			
OCT	51	21	19
NOV	NA	26	NA
DEC	47	25	24
JAN	50	4	14
FEB	46	2	13
MAR	51	26	19
APR	55	15	19
MAY	73	23	21
JUN	85	1	56
Avg	57	16	23

Squadron No.6

DATE	%FMC	A-799	DMMH/FH
1991			
APR	57	16	13
MAY	65	23	24
JUN	75	20	25
JUL	66	34	29
AUG	68	23	22
SEP	67	18	22
OCT	NA	24	NA
NOV	80	12	35
Avg	68	21	24

LIST OF REFERENCES

Chief of Naval Operations, OPNAV Instruction 4790.2E, *Naval Aviation Maintenance Program, Volume III, CH-1*, p.16-10, 1 Jun 1990.

Commander Fighter Airborne Early Warning Wing, U.S. Pacific Fleet, *COMFITAEWWINGPAC INSTRUCTION 1540.1*, 29 May 1992.

Commander Fighter Airborne Early Warning Wing, U.S. Pacific Fleet, *COMFITAEWWINGPAC INSTRUCTION 3500.3*, 13 Mar 1989.

Gibson, R.S., and Orlansky, J., *Performance Measures for Evaluating the Effectiveness of Maintenance Training*, Institute for Defense Analyses, 1986.

Goldstein, L.G., *Training in Organizations*, 3rd ed., p.3 and pp.181-221, Brooks/Cole Publishing Co., 1993.

Horowitz, S.A., and Angier, B.N., *Costs and Benefits of Training and Experience*, pp.70-96, Defense Research Group Panel on the Defense Applications of Operational Research, 1985.

Johnson, B., Fly Navy, p.11, William Morrow and Company, INC., 1981.

Johnson, S.C., McConnell, R.D., and Murdock, D.H., *An Examination of the Impact of Installation Level Training Using Simulators on F-16 Unit Maintenance Productivity*, Management Consulting and Research, Inc., 1983.

Ledeboer, G.J., *Computer-Based Training Applied to the U.S. Navy Maintenance Training Improvement Program*, p.82, Master's Thesis, Naval Postgraduate School, Monterey, California, September 1988.

Orlansky, J., and String, J., *The Performance of Maintenance Technicians on the Job*, pp.4-13, Institute for Defense Analyses, 1981.

Peterson, R. O., ed., "Determining the Payoff of Management Training, Chapter 1: *Designing Guidelines for Evaluating the Outcomes of Management Training*, p.10, by Jackson, S., and Kulp, M.J.," Paper No. 3 ASTD Research Series from A Series of Research Papers and Discussions Presented at the ASTD First Annual Invitational Research Seminar, Pomona, CA, 31 October through 2 November, 1978.

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Naval Aviation Depot
Naval Air Station, North Island
San Diego, CA 92135-5112