A RAND NOTE

Assessment of Patriot Air Defense System Operator Proficiency: Design Issues

Bruce R. Orvis, Michael T. Childress,
J. Michael Polich

August 1989

RAND

This research was sponsored by the United States Army under Contract No. MDA903-86-C-0059.

The RAND Publication Series: The Report is the principal publication documenting and transmitting RAND's major research findings and final research results. The RAND Note reports other outputs of sponsored research for general distribution. Publications of The RAND Corporation do not necessarily reflect the opinions or policies of the sponsors of RAND research.

Published by The RAND Corporation
1700 Main Street, P.O. Box 2138, Santa Monica, CA 90406-2138

A RAND NOTE

N-2891-A

Assessment of Patriot Air Defense System Operator Proficiency: Design Issues

Bruce R. Orvis, Michael T. Childress,
J. Michael Polich

August 1989

Prepared for
The United States Army

RAND

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

PREFACE

This Note contains a research design developed by RAND to assess the performance of Army personnel in operating the PATRIOT air defense missile system. The overall purpose is to improve the ability of the Army Training and Doctrine Command (TRADOC) to set appropriate performance standards and training resource needs and to respond to Congressional requests for quantitative evidence linking personnel quality with Army operational performance.

The study is one of several TRADOC-sponsored research efforts on soldier performance. The RAND Arroyo Center is conducting related studies in the areas of communications and electronic system maintenance under its Manpower, Performance, and Training Program. In addition, TRADOC, the U.S. Military Academy, and the Army Research Institute are organizing similar studies examining armored vehicle and artillery operations.

This Note is intended to document the design of an in-progress study. As data become available, it will be supplemented with RAND analytic reports including statistical estimation of relationships and models of the implications of those relationships for battlefield operations.

The Arroyo Center

The Arroyo Center is the U.S. Army's Federally Funded Research and Development Center for studies and analysis operated by The RAND Corporation. The Arroyo Center provides the Army with objective, independent analytic research on major policy and management concerns, emphasizing mid- and long-term problems. Its research is carried out in five programs: Policy and Strategy Studies; Force Development and Employment; Readiness and Sustainability; Manpower, Training, and Performance; and Applied Technology.

Army Regulation 5-21 contains basic policy for the conduct of the Arroyo Center. The Army provides continuing guidance and oversight through the Arroyo Center Policy Committee, which is co-chaired by the Vice Chief of Staff and by the Assistant Secretary for Research, Development, and Acquisition. Arroyo Center work is performed under contract MDA903-86-C-0059.

The Arroyo Center is housed in RAND's Army Research Division. The RAND Corporation is a private, nonprofit institution that conducts analytic research on a wide range of public policy matters affecting the nation's security and welfare.

Stephen M. Drezner is Vice President for the Army Research Division and Director of the Arroyo Center. Those interested in further information concerning the Arroyo Center should contact his office directly:

Stephen M. Drezner
The RAND Corporation
1700 Main Street
P.O. Box 2138
Santa Monica, CA 90406–2138

SUMMARY

The PATRIOT missile system, the most modern and automated of the Army's Air Defense Artillery systems, protects U.S. and NATO assets from the high- to medium-altitude enemy air threat. This Note describes a research design to assess the performance of PATRIOT enlisted operators and to link that performance to the outcomes of simulated air battles. The study is one of several research efforts sponsored by TRADOC to develop quantitative analyses based on objective measurement of soldier and unit performance. The overall purpose is to improve the Army's ability to set appropriate performance standards and training resource needs and to respond to Congressional requests for quantitative evidence linking personnel quality with Army operational performance.

The basic building block of the PATRIOT system is a firing battery or "fire unit," which includes missile launchers, radar and communications equipment, and an Engagement Control Station (a mobile shelter containing display screens, communications facilities, and computer consoles). During an air battle, the key engagement decisions in a PATRIOT battery are made by one officer (Military Occupational Specialty 14E) and one enlisted person (MOS 24T), who operate the Engagement Control Station. At battalion level (the next higher echelon), a comparable officer-enlisted pair operate a similar facility, which controls the activities of three batteries.

At battery level, MOS 24T personnel help the officer by playing the role of Tactical Control Assistant (TCA); at battalion level, they play the role of Tactical Director Assistant (TDA). The research will examine the efficiency and effectiveness with which the TCA and TDA are able to:

- Protect valuable assets, engage enemy aircraft, and assist in the protection of friendly aircraft as is required for success during air battles (TCA); and
- Direct fire units to engage specific aircraft in order to protect assets and destroy enemy aircraft (TDA).

The study examines how differences in personnel quality and training background affect the execution of TCA and TDA functions and the outcomes of air battles. All of the Army's MOS 24T soldiers at skill levels 1 and 2 will be tested, including students finishing Advanced Individual Training (AIT) and the members of all PATRIOT units stationed both in the United States and in Europe. We estimate that up to 300 unit personnel and 150 students will be tested during the study period, from December 1988 through June 1989.

The study will use the PATRIOT Conduct of Fire Trainer (P-COFT), a computer-controlled, high-fidelity simulation facility consisting of eight operator consoles. The consoles can be operated independently to simulate autonomous fire unit operation or in a netted configuration to simulate fully interactive battalion operation.

Four 20-minute air battles will be simulated. The four scenarios have been developed especially for this test: an area defense scenario, a point defense scenario, a mixed (area and point defense) scenario, and a battalion scenario. The scenarios include realistic wartime-related operations and events and provide a meaningful test of the performance of air defense missions for both AIT students and unit members. In addition, unit personnel will complete a written test measuring their knowledge of proper tactical operating procedures, and all examinees will complete a test on system initialization procedures.

Two personnel will be tested simultaneously. After a briefing describing the purpose and procedures of the test, they will be asked to complete a short background questionnaire. They will then be tested on the simulated air battles and written examinations. Just before the beginning of each scenario, the examinee will be provided with written instructions concerning his mission, the applicable air defense conditions, and specified tactics. The order of written test completion and air battle simulation will be reversed for the two examinees, so that they never participate in the same component of the test at the same time.

The P-COFT facility computer will automatically tabulate all air battle switch action and outcome records. We plan to concentrate on four overall measures of effectiveness, representing success in the missions of TCA point defense, TCA area defense, TDA operations, and identification of friends and foes (IFF). Additional supporting measures will include compliance with tactics and doctrine, compliance with communication received, and knowledge of initialization procedures.

The study plan outlines specific test factors (e.g., damage to each asset, hostile aircraft destroyed, total missiles used, execution of cease fire/engagement commands) that will be available to provide the appropriate measures of effectiveness and performance. We intend to model the effects of various soldier characteristics on these performance measures, assessing the effects of such variables as aptitude scores, educational background, training history, and previous assignments in PATRIOT and other air defense jobs.

ACKNOWLEDGMENTS

This study was made possible by the support of the offices of the Commanding General and the Deputy Chief of Staff for Resource Management, U.S. Army Training and Doctrine Command. Particular thanks are due to General Maxwell Thurman, Brigadier General Theodore Stroup, Lieutenant Colonel David Block, and Major Robert Donoho for their encouragement and efforts. We are also grateful for design assistance and support to the U.S. Army Air Defense Artillery School at Fort Bliss and the 32nd U.S. Army Air Defense Command in Germany, particularly to Major General Donald Infante, Commanding General, USAADASCH, and Major General James Cercy, Commanding General, 32nd AADCOM.

At Fort Bliss, we profited from advice and assistance from Colonel William Miller, Director of Training and Doctrine; Colonel John McKinney, former Director of the PATRIOT Department; Paul Gusset, Chief of the Courseware Development Division (CDD); and Anthony Bush and Gail Levitt, who are responsible for the project office. Very special thanks are due to Andrew Washko, Chief of the Courseware Branch of CDD, and to his staff for their continuing and invaluable support in the development of the air battle scenarios to be used in the study. In the 32nd AADCOM, we are grateful to Colonel Neal Delisanti, formerly G-3; to the personnel of the P-COFT facility in Darmstadt, Germany; and to Barry Miller of Sanders Associates, Inc. for their counsel and support. At RAND, Alvin Ludwig assisted in drafting this Note, James Kahan provided a thoughtful technical review, and Kerrie Avery assisted in document preparation. Finally, we want to express our appreciation to Ellen Penington, our on-site expert consultant at Fort Bliss, who played a key role in the study design and pretesting.

CONTENTS

PREFACE iii

SUMMARY v

ACKNOWLEDGMENTS ix

TABLES xiii

Section

I. INTRODUCTION 1
- Background and Objective 2
- Basic Approach 3
- Outline 4

II. RESEARCH APPROACH 5
- Function and Specialty Tested 5
- Testing Environment 7

III. STUDY DESIGN 9
- Testing Components 9
- Examinees and Schedule 11
- Specific Procedures 13
- Performance Measures and Analysis 14

BIBLIOGRAPHY 17

TABLES

1. Worldwide distribution of MOS 24T personnel by grade 12
2. AFQT category distribution of MOS 24T. 12
3. AIT graduation dates for MOS 24T 13
4. Measures of effectiveness for PATRIOT operator performance. 15
5. Specific test factors related to measures of effectiveness (MOEs). 16

I. INTRODUCTION

This Note describes plans for research to assess the proficiency of enlisted personnel who help to operate the PATRIOT air defense missile system. The tasks performed by these soldiers, who are classified in Military Occupational Specialty (MOS) 24T, are necessary to engage enemy aircraft and to protect friendly assets during combat.

The PATRIOT is the Army's most advanced air defense system, designed to meet the medium- to high-altitude air threat of the 1980s and beyond. It is capable of simultaneously engaging multiple targets in a highly saturated air environment, using advanced features in its radar, missile guidance, and computer and automation systems.[1] The basic building block of the PATRIOT system is a firing battery or "fire unit," which includes missile launchers, radar and communications equipment, and an Engagement Control Station (a truck-mounted shelter containing display screens, communications facilities, and computer consoles). During an air battle, the key engagement decisions in a PATRIOT battery are made by one officer (Tactical Control Officer—TCO) and one enlisted person (Tactical Control Assistant—TCA) who, performing discrete tasks, operate the Engagement Control Station.[2] A similar officer-enlisted pair play the main roles at the next higher echelon, in a PATRIOT battalion composed of three batteries.[3] This study aims to evaluate the abilities of these enlisted personnel and the effects of their performance on the outcomes of simulated air battles.

There are several reasons for assessing the performance of PATRIOT system operators:

- To derive statistical estimates of the effects of personnel quality and experience on the outcomes of air battles,

---

[1]Key features are the multifunction phased array radar, track-via-missile guidance, and computer-automated operations to process information and control missile launches.

[2]The station's crew also includes a communications operator in MOS 31M, but that person is not directly involved in air battle operations.

[3]Eventually, six batteries will be fielded per battalion.

- To ensure the results apply to a modern air defense system operating in a wartime-like environment,
- To provide test measures directly linked to air battle outcomes (asset damage and aircraft engagements), and
- To assess the effects of personnel quality for both newly trained personnel and experienced unit members.

BACKGROUND AND OBJECTIVE

In the past few years, the U.S. Army has acquired modernized equipment with the potential to greatly expand unit combat capability. Realizing that potential, however, depends on the quality of the Army's people and the training opportunities they receive. In this decade, the Army has enjoyed unprecedented levels of quality among recruits and increased levels of seniority, experience, and training among its more senior personnel.[4] But emerging constraints on Defense budgets are likely to limit the Army's future ability to secure the numbers of high-quality recruits to which it has become accustomed and to maintain current levels of training resources.

Indeed, decisionmakers in the Army, OSD, and the Congress are increasingly scrutinizing recruiting and training budgets.[5] To establish resource needs credibly, and to most effectively utilize the resources that are allocated, the Army needs reliable, quantitative analyses of soldier performance and its determinants, including such broad categories of training resources as personnel quality, opportunity to train on tactical equipment, and access to training devices and simulators.

The U.S. Army Training and Doctrine Command (TRADOC) has primary responsibility for setting the standards for unit and individual training and for determining the required levels of aptitude and performance among trainees.[6] To set

---

[4]Department of Defense, 1985.

[5]For example, the House Appropriations Committee, in its report accompanying the FY 88 military appropriations bill, directed the Department of Defense to develop new methods of linking the educational background and aptitudes of recruits to the ability of units to perform their operational missions.

[6]Training standards are established in various TRADOC-published Soldier's Manuals, ARTEPS (Army Training and Evaluation Programs), and related publications. TRADOC schools set minimum aptitude entry standards for their MOS courses, and TRADOC Pamphlet 601-1 establishes "distribution of quality" criteria for allocating high-quality recruits across functional areas.

these standards, TRADOC needs improved measures of soldier performance based on objective, quantified assessments of individual and unit mission achievement in wartime-related functions.

In the past, most analyses of personnel quality requirements have been carried out by TRADOC schools and have been based on the minimum aptitude levels that recruits need to pass initial skill training courses.[7] The Army's long-range job performance measurement project (called "Project A") seeks to provide more definite linkages between various recruit characteristics and certain measures of hands-on performance on specific critical job tasks.[8] However, to date no one has attempted to obtain a broad measure of actual performance in realistic situations directly linked to wartime conditions and outcomes, while relating that performance to the educational background, aptitude, and job experience/training history of personnel.

This study aims to develop improved databases and analyses for such broad-based performance assessment. The objective is to produce empirically based, quantitative estimates of the linkages among training resources, soldier characteristics, and the job performance of crews and small units. This Note describes such a study in the area of Army air defense, one of several special research efforts in different functional areas. Other areas covered by the series of studies include communications, electronic system maintenance, armored vehicle operation, and artillery operations.[9]

BASIC APPROACH

The primary work of MOS 24T is to operate and provide unit maintenance for the PATRIOT Air Defense Artillery system.[10] This research tests the principal operation functions:

---

[7]Recent school submissions to the TRADOC Distribution of Quality program, which requires schools to justify their quality needs, indicate that this type of analysis continues to predominate.

[8]Eaton, Hanser, and Shields, 1987.

[9]RAND is conducting the studies of communications and electronic system maintenance. Studies in the other areas are being carried out by TRADOC, the U.S. Military Academy, and the Army Research Institute.

[10]We recognize that this test concerns only the operations portions of the MOS; maintenance functions, however, are generically different and are the subject of a separate RAND study.

- *Tactical Control Assistant* (fire unit level). The ability to protect valuable assets, engage enemy aircraft, and assist in the protection of friendly aircraft during air battles.
- *Tactical Director Assistant* (battalion level). The ability to direct fire units to engage specific aircraft to protect assets and destroy enemy aircraft.

As part of this evaluation, knowledge of proper system initialization procedures for both functions will be assessed.

The performance of TCA and TDA functions will be evaluated using the PATRIOT Conduct of Fire Trainer (P-COFT), a high-fidelity, computer-driven training device that represents the principal functions of the actual tactical equipment. The P-COFT contains display screens and operators' consoles; they show incoming aircraft (scripted according to a preestablished scenario), safe passage corridors, defended assets, and other airspace and ground features relevant to the fire unit's mission. During a simulated air battle, the operators track and engage aircraft, and the computer keeps records of all switch actions. As we will describe in detail, the records maintained by the simulator will provide a wide range of effectiveness measures that will be used to evaluate the performance of PATRIOT operators in a realistic, wartime-like environment.

OUTLINE

The remainder of this Note presents the research approach, design, and schedule for the test of PATRIOT operations. Section II describes the approach to be taken in the research, including a description of the high-fidelity simulator from which the performance measures are drawn, the scope of the tasks tested, and the personnel examined. Section III presents the specific research design and includes the detailed procedures for testing.

II. RESEARCH APPROACH

The research will use an existing high-fidelity simulation system, the PATRIOT Conduct of Fire Trainer, and associated written tests of tactical operations and initialization procedures to examine the proficiency of air defense soldiers to perform the PATRIOT TCA and TDA mission. The examinees will be tested on their ability to protect valuable assets, engage enemy aircraft, and assist in the protection of friendly aircraft, both at the fire unit and the battalion level of operations.

FUNCTION AND SPECIALTY TESTED

The Air Defense Artillery protects U.S. and allied assets from enemy air attack and has the further mission of causing maximum attrition of enemy aircraft. The current air defense inventory includes the Redeye, Stinger, Vulcan, Chaparral, Hawk, and PATRIOT systems. The PATRIOT is the most modern and automated of these systems. Together with the Hawk, the PATRIOT provides protection from the high- to medium-altitude threat. It is capable of simultaneously tracking large numbers of aircraft and of engaging and destroying them at varying ranges. U.S. PATRIOT battalions are located either at Fort Bliss, Texas, or in the Federal Republic of Germany.

A PATRIOT fire unit (or firing battery) includes a fire control section and eight launchers. Each launching station loads four missiles. The heart of the battery is the fire control section, which includes an Engagement Control Station (ECS), antenna mast group, radar set, and electric power plant. The ECS, which is a mobile shelter mounted on an M-814 vehicle, is manned by three crew members: one 24T enlisted member and one 14E officer, who together control the air battle; and one 31M enlisted communications operator (who is not directly involved in the air battle). The ECS is the only fire unit equipment manned during tactical operations. It is capable of operation in "autonomous" mode (as a stand-alone facility using its own radar and missiles) and in "centralized" mode (under the direction of a PATRIOT battalion to which it is connected by voice and digital data links).

The PATRIOT Battalion contains three firing batteries, under the direction of the Information and Coordination Central (ICC). The ICC is similar to the ECS in general

appearance and features, except that it monitors a wider sector of operations and directs the activity of subordinate ECSs when the battalion is operating in "centralized" mode.

PATRIOT enlisted personnel fall into one of three classifications: MOS 16T, PATRIOT Missile Crew Member; MOS 24T, PATRIOT Operator and System Mechanic; and MOS 24T with Additional Skill Identifier T5, Intermediate Maintenance Specialist. MOS 16T personnel are responsible for emplacement duties for the PATRIOT equipment. MOS 24T personnel are responsible for operation of the ECS and the ICC, and for unit level maintenance.

This study concentrates on the operator duties of 24T personnel. The key functions are:

- *Tactical Control Assistant (TCA).* Operating at fire unit level, the TCA engages aircraft as they approach defended assets and launches missiles against other aircraft when fulfilling an "attrition" mission, in accordance with tactical standing operating procedures and instructions from higher echelons. The TCA also assists the Tactical Control Officer in identifying aircraft, carries out changes in airspace control methods when necessary, initializes the equipment before a battle, and carries out emergency maintenance duties.
- *Tactical Director Assistant (TDA).* Operating at battalion level, the TDA keeps track of aircraft across areas defended by the battalion's three fire units and directs fire units to engage aircraft in accordance with tactical procedures. He assists the Tactical Director in management of the battalion's assets during the battle and performs other functions similar to those carried out by the TCA.

MOS 24T is awarded after successful completion of 37 weeks of Advanced Individual Training (AIT) at the U.S. Army Air Defense Artillery School, Fort Bliss, Texas. During this period, both ECS and ICC operation training are provided.[1] The training concentrates on system initialization procedures and the asset defense mission. After graduation, MOS 24T personnel receive unit training in these areas. In addition, they receive training in the aircraft attrition mission and in air battle tactics. Tactics

[1]Extensive unit maintenance training is also provided.

include such topics as airspace control methods and rules of engagement.[2] These topics are covered in collective training at Fort Bliss before deployment of the unit to U.S. Army Europe, or, for soldiers shipping directly to Germany, upon arrival at the 32nd Army Air Defense Command (AADCOM). In Germany, 24T personnel receive additional training covering local procedures and priorities.

TESTING ENVIRONMENT

This study uses the P-COFT, which replicates operation of the Engagement Control Station and Information and Coordination Central. P-COFTs are located at the Air Defense Artillery School at Fort Bliss and at the 32nd AADCOM headquarters at Darmstadt, Germany.

Description of the P-COFT

The P-COFT is a computer-controlled, high-fidelity simulation facility consisting of eight operator consoles. The consoles can be operated independently to simulate autonomous ECS (fire unit or battery) operations or in netted configuration to simulate fully interactive battalion operations. The P-COFT duplicates the TCA and TDA consoles in the tactical equipment, consisting of a display screen showing aircraft, airspace, and ground features, along with various panels of switches. The features displayed on the screen are affected by operator actions in the same way they would be in a real ECS or ICC. The P-COFT is driven by a master computer, which, with a real-time interface, tabulates the individual actions taken by the operators and the air battle outcomes resulting from these actions. These data are recorded on a disk, which may be read later for analysis. On behalf of RAND, the P-COFT software contractor, Sanders Associates, Inc., has developed additional, special software for this test to tabulate new measures of individual performance and air battle results. The P-COFT contains a central system manager console from which the air battle scenarios are run, examinees' actions can be monitored, and the system is controlled.

---

[2]Airspace control methods apply to the nonelectronic (passive) means of helping to ensure that hostile aircraft are engaged and that friendly aircraft are not. They include factors such as safe passage corridors (volumes of air space in which it is safe to fly); weapon control volumes (volumes of airspace within which certain engagement rules apply); and speed or altitude restrictions. The rules of engagement specify the tactical operating procedures, i.e., what is to be engaged and what is not, based on the airspace control criteria, electronic identification results, and other factors.

RAND and the Air Defense Artillery School have designed a test of TCA and TDA functions for the ECS and the ICC, respectively. It allows us to examine how differences in personnel quality, job experience, and training background affect the execution of these functions and the outcomes of air battles.

Rationale for Using the P-COFT

We selected the P-COFT as the testing medium first because it provides realistic simulation of TCA and TDA duties, for which the actions and outcomes can be measured objectively and precisely by computer. Second, the results of a given simulation can be translated directly into air battle outcomes. Third, the computer records can provide many details on the process of the battle, including the specific procedural steps that may contribute to desirable or undesirable results. Fourth, unit and battalion level operations can be measured without use of tactical equipment—a considerable advantage given the small number of ECSs and ICCs in existence and the great demand for them. Fifth, the P-COFT permits testing in the same, controlled environment for all soldiers, both at Fort Bliss and in the 32nd AADCOM.

III. STUDY DESIGN

TESTING COMPONENTS

We have designed several procedures to assess capability to perform critical duties that must be accomplished in wartime. The entire testing procedure will be administered and supervised by experienced air defense and RAND personnel.

Simulated Air Battles

Four 20-minute air battles will be simulated. The scenarios have been developed especially for this test by subject matter experts at Fort Bliss and the 32nd AADCOM acting in consultation with RAND. The scenarios are designed to be realistic with respect to required wartime operations and events. They have also been designed to provide a meaningful test of the performance of air defense missions by both recent AIT graduates and experienced unit members. The flight events scripted into the scenarios represent the challenges that can be expected in wartime. They include features such as masking; jamming; varying aircraft headings, formations, speeds, and altitudes; air to surface missiles; and aircraft with varying degrees of identification equipment problems, among other features.[1]

Area Defense Scenario. The area defense scenario typifies operations required during wartime in forward areas. The air defense mission is to destroy the maximum number of enemy aircraft (consistent with prescribed tactical procedures and rules of engagement, including requirements for self-defense). The scenario begins in centralized mode. During this period, the TCA receives from the ICC specific engagement and tactical instructions that must be properly executed. Subsequently, he is instructed to change to autonomous operation of the ECS. During the autonomous period, he is solely responsible for his actions. As is true for all the scenarios, the

[1]For example, aircraft may enter a PATRIOT unit's area on various headings (some threatening defended assets, some not), they may turn or change altitude unexpectedly, they may fly within or outside various corridors and designated airspace volumes, and they may be "masked" by flying behind terrain features such as mountains. The RAND scenarios have been specifically designed to represent these and other complex aircraft behavior patterns that are realistically expected in wartime and that pose challenges to missile system operators who must keep track of numerous events occurring simultaneously.

examinee receives information concerning his mission and the tactics to be followed at the beginning of the scenario. To provide a standardized (and realistic) protocol, the examinee is instructed to use the automatic aircraft identification mode and to assume that the identifications are valid. ("Automatic" in this context means that the computer identifies an aircraft as friendly, hostile, or unknown based on calculations from various input evaluation criteria.)

Point Defense Scenario. The point defense scenario typifies operations required during wartime in rear areas. The air defense mission is to defend the assets assigned to the examinee's fire unit, such as air bases, built-up areas, storage facilities, and other high-priority locations. The scenario is run in autonomous operations. Halfway through the scenario, the TCA is informed that his TCO—the officer with whom he is fighting the air battle—has died and that he must now also assume the officer's function of protecting friendly aircraft (for which he has been trained). During this period, he receives two instructions to carry out changes in the procedures for identifying hostile and friendly aircraft. The first tells him to change the current IFF codes to an alternative set. The second tells him that certain features of the airspace control methods have been compromised; he must now manually identify aircraft to ensure their proper identification as hostile or friendly.[2]

Mixed Scenario. This scenario simulates a wartime situation in which the primary mission is to destroy enemy aircraft and the secondary mission is to defend an air base assigned to the fire unit. Again, the missions must be carried out in a manner consistent with the tactical instructions provided to the examinee just before commencement of the air battle. The scenario is run in autonomous operations.

Battalion Scenario. The battalion scenario typifies ICC operations required during wartime. The air defense mission is to assign individual enemy aircraft to the fire units under the control of the ICC and order their engagement. The order includes the method of fire—the number of missiles to be fired and the timing of the launches.[3] The

---

[2]In this situation, the operator must disregard the identifications generated by the computer for aircraft within the compromised area; instead, he must exercise his knowledge of airspace control methods to make identifications himself according to doctrine and prescribed tactical procedures.

[3]The appropriate number of missiles depends on the number of aircraft in a confined airspace and the degree of threat posed by the aircraft, among other things. The more missiles fired, the greater the probability of destroying the targets; but it is important to conserve the supply of missiles, especially for self-defense.

orders must be issued in accordance with the battalion's mission and the specified tactical instructions. In this scenario, the mission is asset defense.

Written Tests

In addition to being tested on their performance in fighting the simulated air battles, the examinees will be required to complete written tests. Unit members will complete one test measuring their knowledge of proper tactical operating procedures and a second test measuring their knowledge of system initialization procedures at the unit and battalion levels.[4] Soldiers just concluding AIT will complete only the initialization test, since tactics are essentially taught in unit training procedures. Each test will consist of 25 multiple choice questions. The tactical test questions are drawn from official sets of questions used to test unit members' tactical qualification for TCA duties. The initialization test is drawn from official items used to assess comprehension of initialization procedures during AIT.

The examinees will also complete a background questionnaire that collects information on their education, training history, unit assignments, history of job responsibilities, and air defense experience. This information will be used to supplement official records concerning their performance on the Armed Services Vocational Aptitude Battery.

EXAMINEES AND SCHEDULE

All MOS 24T soldiers at skill levels 1 and 2 will be tested, including personnel concluding AIT and the members of all PATRIOT units stationed both in the continental United States and Europe.[5] The test excludes skill levels 3 and 4 (senior personnel) because our primary concern is with the required quality of *recruits*. The current distribution of MOS 24T personnel worldwide is provided in Table 1. Table 2 shows the AFQT Category distribution for MOS 24T. Finally, Table 3 shows scheduled graduation dates for the AIT classes that conclude during the testing period and, thus, will be

---

[4]Initialization consists of entering into the computer parameters that govern air battle operations, such as terrain features, airspace control methods, and codes for electronic identification of friendly and hostile aircraft.

[5]Soldiers in the junior grades (E-1 through E-4) are at skill level 1; they typically have one to four years of service. Soldiers at grade E-5 are at skill level 2 and normally in their second term of enlistment.

Table 1

WORLDWIDE DISTRIBUTION OF MOS 24T PERSONNEL BY GRADE[a]

Command	E1–E3	E4	E5	E6	E7	E8–E9	Total
USAREUR	18	115	34	74	42	15	298
FORSCOM	58	35	29	35	23	4	184
TRADOC	7	29	24	87	57	14	218
AMC	0	15	6	9	7	3	40
Others	0	1	0	1	0	0	2
Total	83	195	93	206	129	36	742

[a]Grades E1–E4 correspond to skill level 1, grade E5 corresponds to skill level 2, grade E6 to skill level 3, grade E7 to skill level 4, and grades E8-E9 to skill level 5.

Table 2

AFQT CATEGORY DISTRIBUTION OF MOS 24T

		Percent of Total		
AFQT Group	AFQT Range (percentiles)	Skill Levels 1–2	Skill Levels 3–5	All Skill Levels
I	93–99	6.2	9.8	7.6
II	65–92	47.0	37.9	43.5
IIIA	50–64	24.7	20.6	23.1
IIIB	31–49	19.3	23.7	21.0
IV	10–30	2.8	8.0	4.8

included in the test. AIT students will be tested after they have received all applicable training instruction, near the end of their AIT course. Unit members will be scheduled to accommodate unit training activities and exercises.

Final phases of software testing and procedural pretesting were completed during the months of September to November 1988. Testing begins in December at Fort Bliss and in January in Germany. At Fort Bliss, we expect to test all graduating AIT students in MOS 24T and all MOS 24T personnel, skill level 1 and 2, in school support and Forces Command units during the period from December 1988 through June 1989. In Germany, unit members will be rotated into the P-COFT facility at Darmstadt in groups of approximately four persons per day, making it possible to test one battalion's 24T personnel, skill level 1 and 2, in two weeks. If this schedule can be maintained, the

Table 3

AIT GRADUATION DATES FOR MOS 24T

Class[a]	Number of Students	Graduation Date
502–88	16	7 Dec 88
503–88	13	7 Dec 88
4–88	15	24 Jan 89
504–88	16	22 Feb 89
505–88	16	22 Feb 89
506–88	16	16 Mar 89
507–88	14	21 Apr 89
509–88	16	23 Apr 89
1–89	12	20 Jun 89
2–89	13	20 Jun 89
8–88	11	06 Jul 89
10–88	15	06 Jul 89

[a]500 series classes were planned after the initial budget cycle. In other respects, they are the same as the lower number classes. Classes 1–89 and 2–89 have a shorter program of instruction.

testing in Germany could be completed by April 1989. The result will be a sample size of up to 300 unit personnel and 150 AIT students.[6]

SPECIFIC PROCEDURES

Two people will be tested simultaneously. Each pair of examinees initially will be given a short briefing describing the purpose and procedures of the test and assuring them of the confidentiality of the results. They will then be asked to complete the short background questionnaire.

To facilitate the execution of the testing procedures and to prevent possible cooperation between the pair of examinees, the timing of the individual components of the test will be staggered. At no point will the two examinees complete the same written

[6]For AIT personnel, we are not certain of the final number of students who will actually graduate or the number who will be tested in the 20 June cohorts (since they were scheduled for a shorter program of instruction), so the total number of examinees should be about 150. For unit personnel, there is uncertainty depending on the changing number of people who are assigned to actual unit duties as 24Ts and the fraction of personnel who are actually available for testing. Some personnel will be acting in jobs that may make testing inappropriate (e.g., as instructors, aides, or workers in combat development or acquisition jobs) and some will be in transit or otherwise unavailable.

test or fight the same air battle simultaneously. The complete testing procedure will require three hours per pair of examinees.

One of the examinees will begin by taking the simulated air battle portion of the test. After concluding all of the simulated air battles, he will be asked to complete the written initialization test and, if a unit member, the tactical operations test. The second examinee will complete the written test(s) before beginning the first simulated air battle. This procedure ensures that no component of the test is completed simultaneously by the two participants. The order of the air battles will be the same for all examinees: area defense scenario, mixed mission scenario, point defense scenario, and battalion (ICC) scenario. The order is based on providing continuity and an increasing level of difficulty.[7] Just before the beginning of each scenario, the examinee will be provided with written instructions concerning his mission and the applicable air defense conditions and tactics. The scenarios have been written to allow the participants one minute to set up their consoles before the first engageable aircraft appear.

PERFORMANCE MEASURES AND ANALYSIS

The P-COFT facility computer will tabulate all air battle switch action and outcome records automatically. RAND will develop additional software to analyze these records.

Table 4 shows the measures of effectiveness that will be used to evaluate the performance of the examinees. The measures are divided into primary and supporting measures. The primary measures reflect the direct outcomes of the air battles, such as asset damage and specific aircraft engagements. The supporting measures reflect the actions and knowledge that underlie success on the primary measures. Table 5 lists the specific test factors that will be evaluated and relates them to the applicable measures of effectiveness. Each factor will be evaluated separately for each scenario and examinee.

We intend to model the effects of various soldier characteristics on these multiple performance measures using multivariate methods such as regression analysis and analysis of covariance. Although the exact specification of a model and the functional

[7]The increasing level of difficulty and order of the scenarios may facilitate performance in the later air battles to a limited extent for persons who have not performed as TCA/TDAs recently because of practice effects. In our opinion, and by design, this is realistic because such persons would be given some opportunity to practice before participating in a real battle if at all possible.

Table 4

MEASURES OF EFFECTIVENESS FOR PATRIOT OPERATOR PERFORMANCE

Primary Measures
A. Success in TCA point defense mission
B. Success in TCA area defense mission
C. Success in TDA mission
D. Identification of friends and foes
Supporting Measures
E. Compliance with tactics/doctrine
F. Compliance with communications received
G. Knowledge of initialization procedures

form cannot be determined in advance of examining the data, we expect to include as predictor variables an array of test scores such as AFQT and Army aptitude indices; educational level and years of education; training background; experience factors such as time since AIT, time in MOS, location of service, and type of unit (e.g., PATRIOT and other air defense units); and specific job history variables such as extent and recentness of previous service as a TCA, TDA, and maintainer. These data will be obtained where possible from official records, such as accession testing files of the Defense Manpower Data Center and Army records from the Enlisted Master File, supplemented by self-reported questionnaire data obtained directly from the examinees. With this broad array of factors in the analysis, we expect that extraneous effects will be well controlled and that the analysis will permit fairly precise estimation of the effects for personnel quality.

Table 5

SPECIFIC TEST FACTORS RELATED TO MEASURES OF EFFECTIVENESS (MOEs)

	MOEs						
	Primary				Supporting		
Factors	A	B	C	D	E	F	G
Scenario Tests (Forward, Mixed, Rear, Battalion)							
Number of hits to each asset by priority of asset	X		X				
Number of hits to ECS	X	X	X				
Number of hostile aircraft engaged (IAW tactics and not IAW tactics)[a]	X	X	X	X			
Number of friendlies engaged	X	X	X	X			
Total missiles used and missile conservation					X		
Fire patterns IAW tactics and not IAW tactics (number of shoot-look-shoot, ripple, salvo by type of target—e.g., raid size, threat code level)					X		
Tactical correctness of position of aircraft and flight path at launch					X		
Engagement of specified ATC targets and slow speed targets					X		
Console setup					X		
Execution of cease fire, hold fire, and engagement commands						X	
Success in manual aircraft identification procedures				X	X	X	
Execution of IFF code change					X	X	
Written Tests							
Score on written initialization test adapted from the Program of Instruction							X
Score on 32nd AADCOM-adapted TCA qualification test (units)					X	X	X

[a]IAW = "in accordance with."

BIBLIOGRAPHY

Army, *PATRIOT Individual and Collective Training Plan (ICTP)*, U.S. Army Air Defense Artillery School, Fort Bliss, TX, 2 December 1987.

Army, Program of Instruction, *PATRIOT Air Defense Officer*, Course Number 2F-14E, U.S. Army Air Defense Artillery School, Fort Bliss, TX, 7 December 1987b.

Army, Program of Instruction, *PATRIOT Operator and System Mechanic*, Course Number 632–24T10, U.S. Army Air Defense Artillery School, Fort Bliss, TX, 4 November 1987c.

Army, Program of Instruction, *PATRIOT Operator and System Mechanic*, Course Number 632-24T1/2/3/4-T, U.S. Army Air Defense Artillery School, Fort Bliss, TX, January 1988a.

Army, Program of Instruction, *PATRIOT Operator and System Mechanic-BNCOC*, Course Number 632-24T30, U.S. Army Air Defense Artillery School, Fort Bliss, TX, 8 May 1987d.

Army, Soldier Training Publication, *PATRIOT Operator and System Mechanic, MOS 24T Skill Level 1, Draft*, STP 44-24T1-SM, U.S. Army Air Defense Artillery School, Fort Bliss, TX, March 1988b.

Army, Training Manual 9-1430-600-10-1, *PATRIOT Air Defense Guided Missile System: Engagement Control Station, Guided Missile, Truck Mounted: AN/MSQ-104*, Headquarters, Department of the Army, October 1983.

Army Training and Doctrine Command, TRADOC Pamphlet 601–1, *Soldier Quality (SQ) Program*, 15 April 1988.

Army Training and Evaluation Program, ARTEP 44–635, *Air Defense Artillery Battalion: PATRIOT*, Headquarters, Department of the Army, 12 July 1985.

Department of Defense, Office of the Assistant Secretary of Defense (Force Management and Personnel), *Joint-Service Efforts To Link Enlistment Standards to Job Performance*, Sixth Annual Report to the House Committee on Appropriations, December 1987a.

Department of Defense, Office of the Assistant Secretary of Defense for Manpower, Installations, and Logistics, *Quality of Military Enlisted Personnel*, Report to the House and Senate Committees on Armed Services, Washington, D.C., 1985.

Department of Defense, Office of the Secretary of Defense, *Report to Congress—Impact of Recruit Quality on Military Readiness*, Memorandum, December 1987b.

Eaton, Newell Kent, Lawrence M. Hanser, and Joyce L. Shields, "Validating Selection Tests Against Job Performance," in Joseph Zeidner (ed.), *Human Productivity Enhancement: Organizations, Personnel, and Decision Making*, Volume 2, New York, Praeger, 1987.

House of Representatives, Report from the Committee on Appropriations (HAC), 1988.

Hughes, Charles, *Air Defense Accessions Update*, TRASANA TEA-40-81, U.S. Army TRADOC Systems Analysis Activity, White Sands Missile Range, NM, October 1981.

LaRocque, Robert, *Air Defense Accessions Training Effectiveness Analysis, Final Report* (Volumes I and II), TRASANA TEA 7-81, U.S. Army TRADOC Systems Analysis Activity, White Sands Missile Range, NM, March 1981.

Rossmeissl, Paul G., Mary Ann Alderson, Linda J. Shotzbarger, and David L. Payne, *The Cognitive Requirements Model: An Approach to Job Engineering*, Hay Systems Technical Report, Hay Systems, Inc., Washington, D.C., 1988.

Vargas, Abel A., et al., *PATRIOT Post Fielding Training Effectiveness Analysis*, TRAC-WSMR-TEA-17-87, U.S. Army TRADOC Systems Analysis Activity, White Sands Missile Range, NM, June 1987.

Wigdor, A. K., and B. F. Green, *Assessing the Performance of Enlisted Personnel: Evaluation of a Joint-Service Research Project*, National Research Council, Washington, D.C., 1986.