Study
Report
2002-01

Development of a Personal Computer-Based Enlisted Personnel Allocation System (PC-EPAS)

Peter M. Greenston
U.S. Army Research Institute

David Mower and Steven W. Walker
BTG, Inc.

Mary Ann Lightfoot and Tirso E. Diaz
Human Resources Research Organization

Peter B. McWhite
McWhite Scientific

Ruth Ann Rudnik
Consultant

United States Army Research Institute
for the Behavioral and Social Sciences

October 2001

U.S. Army Research Institute
for the Behavioral and Social Sciences

A Directorate of the U.S. Total Army Personnel Command

EDGAR M. JOHNSON
Director

Technical Review by

Leonard A. White
Mike A. Fischl

NOTICES

DISTRIBUTION: Primary distribution of this Study Report has been made by ARI. Please address correspondence concerning distribution of reports to: U.S. Army Research Institute for the Behavioral and Social Sciences, Attn: TAPC-ARI-PO, 5001 Eisenhower Ave., Alexandria, VA 22333-5600.

FINAL DISPOSITION: This Study Report may be destroyed when it is no longer needed. Please do not return it to the U.S. Army Research for the Behavioral and Social Sciences.

NOTE: The findings in this Study Report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
October 2001

3. REPORT TYPE AND DATES COVERED
Final, Aug. 1997 - May 1999

4. TITLE AND SUBTITLE
Development of a Personal Computer-Based Enlisted Personnel Allocation System (PC-EPAS)

5. FUNDING NUMBERS
PE 465803
PR D730
WU 1331
TA C05

MDA 903-93-D-0032 (DO#0063)

6. AUTHOR(S)
Peter M. Greenston (U.S. Army Research Institute); David Mower & Steven Walker (BTG, Inc.); Mary Ann Lightfoot & Tirso E. Diaz (Human Resources Research Organization); Peter B. McWhite (McWhite Scientific); Ruth Ann Rudnik (Cons.)

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Research Institute for the Behavioral & Social Sciences
5001 Eisenhower Avenue, Alexandria, VA 22333-5600

Human Resources Research Organization
66 Canal Center Plaza, Suite 400, Alexandria, VA 22314-1591

8. PERFORMING ORGANIZATION REPORT NUMBER

FR-WATSD-99-26

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

U.S. Army Research Institute for the Behavioral & Social Sciences
5001 Eisenhower Avenue
Alexandria, VA 22333-5600

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

Study Report 2002-01

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

This report summarizes the development of the PC-Based Enlisted Personnel Allocation System (EPAS) through completion of the Functional Description phase (circa 1998) . EPAS is a software system designed to introduce person-job-match optimization into REQUEST, the Army's training reservation system. This report reflects the results of research conducted and sponsored by the U.S. Army Research Institute over the 1993 - 1998 period. This work established the feasibility of using sophisticated optimization procedures to improve classification efficiency, as well as the additional classification gains made possible by utilizing measures of soldier performance as assignment composites in the classification process. The production version of EPAS, designed as an enhancement to and subsystem of REQUEST, will be transparent to Army applicant and career counselor. Evaluation field-testing is scheduled for FY 2002- 2003.

14. SUBJECT TERMS
personnel selection and classification; person-job match; military personnel management

15. NUMBER OF PAGES
116

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	Unlimited

Study Report 2002-01

Development of a Personal Computer-Based Enlisted Personnel Allocation System (PC-EPAS)

Peter M. Greenston
U.S. Army Research Institute

David Mower and Steven W. Walker
BTG, Inc.

Mary Ann Lightfoot and Tirso E. Diaz
Human Resources Research Organization

Peter B. McWhite
McWhite Scientific

Ruth Ann Rudnik
Consultant

Selection and Assignment Research Unit
Michael G. Rumsey, Chief

U.S. Army Research Institute for the Behavioral and Social Sciences
5001 Eisenhower Avenue, Alexandria, Virginia 22333-5600

October 2001

Army Project Number
20465803D730

Personnel and Training
Analysis Activities

FOREWORD

Classification is the process of assigning new enlisted personnel to initial job training in the Army. Investigations of improved methods for doing this have been a prominent part of the research program of the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) since shortly after World War II. The immediate antecedent of this work was ARI's Project B research, conducted over the 1982 – 1989 period, which led to the testing of a mainframe prototype. PC prototype development began in the fall of 1993 and was largely completed by the spring of 1997, at which time the Deputy Chief of Staff for Personnel (DCSPER) recommended that ARI continue the work and move toward implementation. This report summarizes the development of a Personal Computer-Based Enlisted Personnel Allocation System (EPAS), designed to enhance the effectiveness of classification, at the point at which the Functional Description (FD) was completed. Army management reviewed the FD in the fall of 1998, and the Director of Military Personnel Management (DMPM) recommended that ARI conduct a field test evaluation. The evaluation is scheduled for the 2001 – 2003 period.

The Army currently takes a minimum enlistment standards approach to classification. EPAS, working as a subsystem of the Army's training reservation system, is an attempt to go beyond minimum standards and make better use of each recruit's potential. Simulation testing of the prototype models indicates the likelihood of large gains in classification efficiency, and the objective of the field test is to confirm these gains in the presence of real-world constraints and decision-making.

The goal of the Selection and Assignment Research Unit (SARU) of ARI is to conduct research, studies, and analysis on the measurement of aptitudes and performance of individuals to improve the Army selection and classification, promotion, and reassignment of officers and enlisted soldiers. This research will provide the foundation for recommended improved aptitude measurement and classification procedures for enlisted personnel.

Zita M. Simutis

ZITA M. SIMUTIS
Technical Director

Development of a Personal Computer-Based Enlisted Personnel Allocation System (PC-EPAS)

EXECUTIVE SUMMARY

Research Requirement:

Classification is the matching of recruits into their entry job training. The U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) has been conducting research into better classification methods and developing the Enlisted Personnel Allocation System (EPAS), with the aim of enhancing the Army's current training reservation system, known as REQUEST. A very large-scale ARI effort called Project B explored alternative approaches to the Army classification issue, and led to the development in late 1980's of a mainframe-based EPAS prototype. This work was continued in the mid – 1990's with the development and testing of a PC-based EPAS prototype, designed to enhance REQUEST by pushing it toward more effective classification. Parallel research growing out of Project B has developed better aptitude area composites and classification-efficient job families and found that additional classification gains are made possible with their use. The purpose of this report is to summarize the PC-EPAS development work, and to describe the design for the operational version of EPAS and identify outstanding operational issues.

Findings:

EPAS is designed to enhance REQUEST by introducing optimization methods into what is a sequential assignment process. This is done by treating the assignment process as two phases. In the first phase, a linear programming model represents the (forecasted) monthly flow of applicants and availability of training class seats over the recruiting year. Applicants are categorized into supply groups by their demographics and aptitude profiles. The optimal allocation or matching of (applicant) supply groups to military occupational specialty (MOS) training classes is determined. The optimal allocation is the one that maximizes predicted performance for an annual accession cohort, while meeting accession and training management goals. (See "Description of the Aggregate Allocation Model" for a discussion of predicted performance and the optimization model.) The model solution is updated weekly and used to generate an ordered list of MOS training recommendations that best match each supply group with training requirements. In the second phase, that of actual applicant assignment, these recommendations are merged with those generated by existing REQUEST procedures and presented to the applicant by the career counselor.

The PC-EPAS prototype has been tested in planning and simulation modes. Planning mode refers to the linear programming model solution to the aggregate allocation problem. Simulation mode testing refers to the application of the model solution, called the EPAS optimal guidance, to a simulated stream of applicants arriving at the career counselor's station. What deserves emphasis here is that the simulated flow of applicants is directed only by the EPAS optimal guidance, derived in a prior phase from the EPAS model. The results indicate how well the EPAS optimal guidance has transmitted the training management objectives and constraints, and as such represent a first test of EPAS in a simulated operational mode. Simulation testing

has shown that the two-phase approach is robust in the following sense: the application of the EPAS optimal guidance results in simulated job matches that yield improved soldier performance while achieving "respectable" levels of military occupational specialty (MOS) job fill.

The proposed design for incorporating EPAS optimal guidance into REQUEST calls for merging of the EPAS optimal guidance with the REQUEST ordered list generated for the applicant. The merged ordered list would contain those job training recommendations appearing in both input lists, and in the EPAS optimal guidance list order. This ensures that REQUEST continues to provide the final screening, while allowing the optimal guidance to affect the ordering. In order for this to work as designed, certain REQUEST procedures, which perform flow control functions, should give way so as to not unduly restrict the scope of the REQUEST ordered list.

Simulation testing has shown that large gains in (recruit) performance could be obtained through the introduction of optimized classification. We estimate that it would cost an additional $150M per cohort using existing procedures -- by recruiting additional high-quality candidates -- to achieve the performance gains obtainable through EPAS. As mentioned, "parallel" research into classification methods has demonstrated the possibility of additional improvement in soldier performance with the use of better composites and classification-efficient job families. These results have been substantiated in testing using the PC-EPAS prototype, and point the way towards a significantly augmented Army classification capability.

Utilization of Findings:

The model and procedures described in this report constitute the core of the EPAS Functional Description, and will be used as a guide in the development of the EPAS production model enhancement to REQUEST and for evaluation field-testing of the enhancement.

TABLE OF CONTENTS

Introduction

Personnel Classification in the Army

In the years just preceding World War II, the Personnel Research Section of the Adjutant General's Office in the War Department developed a new mental ability test called the Army General Classification Test (AGCT). The AGCT was designed to measure learning ability and soldier performance and became the selection instrument for draftees during the war. It was also used to select men for officer candidate schools. The AGCT measured verbal, quantitative, and spatial aptitudes (Harrell, 1992).

By the middle of World War II, psychologists realized that new technologies and military equipment added new complexities and greater specialization to military jobs than had existed during World War I. Military psychologists saw the need to respond to these changes by creating new employment testing methods that would go beyond simple selection. They started investigating the feasibility of using the AGCT, a mechanical aptitude test, and a clerical test for scientifically matching soldiers to military specialties. This was an important extension of the common sense approach to person-job matching spontaneously used by field commanders in World War I, and exemplifies the close association of practice and science in applied personnel psychology.

There is very little record of the first classification testing efforts, probably because the emphasis was on meeting critical wartime needs. The Army Air Forces Aviation Psychology Program of World War II included the earliest classification studies aimed at assigning aircrew officers to pilot, navigator or bombardier specialties. Aircrew officer classification R&D was transferred to the Air Force when it was created as an independent branch in 1947. The Airman Classification Battery, which evolved directly from the Army aviation psychology program, was implemented in 1948. It measured verbal and quantitative aptitudes, dial and table reading, aviation information, current affairs, perceptual speed and geographical memory. It also included tests that presaged the Armed Services Vocational Aptitude Battery (see below) technical tests and a biographical inventory (Weeks et al., 1975).

Closely following the end of World War II military psychologists and other applied scientists and engineers, who assisted in the selection, classification, training and logistical management of soldiers during the war, began to formalize their views and methods of military classification. Two strands of research were necessary to create an effective process for optimally matching people to jobs: personnel classification testing and operations research. Personnel classification theory, research and testing methods provide the content for classification systems. Operations research provides mathematical models of the person-job matching process.

A small group of military and university psychologists were instrumental in identifying the classification function in personnel management, and began to specify its parameters and to develop a sub-field of classification employment testing in the late 1940's and throughout the 1950's (Thorndike, 1950). Hubert E. Brogden, Chief Scientist of ARI in the 1950s, laid down the theoretical foundation for classification, which stands today (Brogden, 1946, 1959).

What was and remains most important about Brogden's work is that he created a scientific definition of classification and delineated the specifications for an effective classification technology. Classification, or optimal person-job matching, is defined as the assignment of each new employee to the job for which he or she is best suited based on valid assessment criteria. We present an updated version of the major classification specifications in Table 1 below.

The Army developed a simplified enlisted personnel classification testing process in 1950. It consisted of the following:

- A set of nine occupational groups of military occupational specialties (MOS) organized into aptitude areas (AA).
- A corresponding set of AA composites, which were good predictors of MOS training success in the AA groups. The composites were simple sums of three or four aptitude tests from the established Army Classification Battery.
- A minimum qualifying AA composite score for each MOS.

The other Services developed comparable systems around the same time. Simplifications were necessary because screening and person-job matching were conducted by hand before computers were introduced into military selection and classification in the mid-1970s. Notwithstanding this introduction, the Army's current classification testing procedure is essentially the same as that developed in the early 1950s.

Table 1. Major Specifications for an Effective Classification Technology

- Classification is warranted when public or private employers have at least several different occupational fields within the organization and large numbers of employees are hired annually for each occupation. These occupations must be at the same level within the organization so job candidates can be evaluated for assignment to jobs in any of the occupations.
- A classification process will benefit an employer when successful job performance in different occupations requires different sets of qualifications, that is, different combinations (or profiles) of intellectual aptitudes, career interests, and work-related personal preferences (e.g., working indoors vs. outdoors, obtaining post-secondary vs. secondary education).
- A classification test battery should have the following characteristics:
  - It must measure a range of work-related aptitudes and, if possible, occupational interests and preferences;
  - It must produce a set of occupational test composites that are valid estimates of occupational success and differentiate the ability requirements of the occupations.
- An optimal classification process based on an effective test battery can produce organizational benefits even if all job applicants are hired. In other words, classification can be worthwhile to an employer even if a selection procedure is not used or no applicants are screened out.
- The cost-effectiveness of a classification process depends upon the following:
  - Costs of recruiting, hiring, training, and compensation;
  - Extent of variation in occupational qualifications;
  - Annual number of employees hired;
  - Number of different occupations to which people can be assigned;
  - Validity of the classification test battery;
  - Extent to which the battery can be used to create differential occupational profiles; and
  - The impacts of practical organizational considerations on the optimal person-job matching process.

The classification battery has evolved and changed, but few modifications have been made to the basic structure of the AA groups of MOS. The most frequent changes have been made to the sets of tests in the AA composites and to the minimum qualifying scores for MOS.

In 1974 the Department of Defense decided that all the services should use a single test battery both for screening enlistees and for assigning them to military occupations. The Armed Services Vocational Aptitude Battery (ASVAB) was selected for this purpose. Periodically, ARI researchers have assessed how well the nine AA composites predict training and on-the-job success. This research has consisted of validation studies that link the ASVAB tests to accurate measures of training and job performance (e.g., the Skill Qualification Test [SQT] of the late1980s).

Background: Quality Issue, Allocation Policy and Classification Research

Historically Congress has taken a strong interest in Service recruiting budgets, given their relatively large size and importance in military manpower planning. These budgets are driven by numbers (i.e., accession requirements) and desired recruit quality levels. The Services propose budgets to attract the best available youth, while Congress aims to provide just enough resources to attract a mix of youth consistent with maintaining a competent military force.[1]

The quality issue was pushed to the fore of the debate on the viability of the All-Volunteer Force with the discovery, in 1980, that the ASVAB battery had been misnormed. Over the 1976 – 1980 period, it turned out that one-half of Army non-prior service recruits had been drawn from the bottom 30% of the eligible youth population, a considerably lower quality level than the goal the Army had set for itself. But how much quality was actually needed – presumably more than the prevailing level -- and what would it cost? The Army could not answer this question, because "in the Service with the most serious quality problem, there was little empirical basis to defend the argument that higher quality increased military capability by improving either training success or job performance" (Armor and Roll, 1994, p.17). Soon after the discovery, the Assistant Secretary of Defense for manpower initiated the Joint-Service Job Performance Measurement (JPM) / Enlisted Standards Project with the charge that "the Services and Office of the Assistant Secretary of Defense (OASD - Manpower, Reserve Affairs & Logistics) must pursue … a long range systematic program of validating ASVAB and enlistment standards against performance on the job".[2] The Job Performance Measurement Project was formally mandated in the FY93 Defense Appropriations bill, which established a "long-term research project to measure the performance of enlisted personnel in a variety of military occupations and to link that measured performance to military entrance standards" (Green, Wing, and Wigdor, 1988, pp. 7-8).

In response to Office of the Secretary of Defense (OSD) guidance, a Deputy Chief of Staff for Operations (DCSOPS) memorandum[3] spelled out the responsibilities of each Army command and staff element in supporting the effort. Deputy Chief of Staff for Personnel (DCSPER) was given the lead responsibility and the Army Research Institute (ARI) was identified as the executing agency. The following objectives were delineated: (a) validation of ASVAB forms against existing and experimental measures of soldier performance; (b) validation of demographic, motivational, environmental, aptitudinal and experiential variables against

---

[1] See Hogan and Harris (1994) for discussion of social policy considerations.

[2] Memorandum from Office of the Assistant Secretary of Defense – Manpower, Reserve Affairs, and Logistics (OASD - MRA&L) to Assistant Secretary of the Army – Manpower and Reserve Affairs (ASA - M&RA), 11 September 1980.

[3] Subject: Army Research Project to Validate the Predictive Value of the Armed Services Vocational Aptitude Battery (ASVAB), 19 November 1980.

performance in training and on the job; and (c) development and validation of Army selection and classification procedures capable of accurately predicting successful performance in training and on the job. The associated goals / payoffs called for in the memorandum are of particular relevance in pointing toward the EPAS work: " (a) the optimal, efficient use of the applicant pool; (b) a method of continuously fine-tuning enlistment standards to required training and job performance standards; and (c) a more accurate, efficient method of placing the right soldier in the right job in the force."

The first stage of the Job Performance Measurement Project was to determine whether job performance could be successfully measured and how best to do so. The JPM Working Group decided to concentrate on the job proficiency of individual first-term incumbents, which had the effect "of emphasizing the job-related aspects of selection and placement, including the statistical prediction of job performance from aptitude tests, the entrance standards for jobs, and the allocation systems" (Green, Wing, and Wigdor, 1988, p. 9). The Army's research program, known as ARI Project A, was designed to evaluate alternative measures of job performance, to validate the existing ASVAB selection and classification battery, and to develop and validate measures of job relevant attributes outside ASVAB's realm, such as spatial and psychomotor ("can do") tests as well as motivation and socialization ("will do") tests.[4] After more than a decade of research, "the Job Performance Measurement Project demonstrated that reasonably good measures of job performance can be developed, and that the relationship between these measures and ASVAB are strong enough to justify its use in setting enlistment standards" (Green and Mavor, 1994, p. 10).

However, in addressing the question of how much quality is needed and what would it cost, a relationship between performance and recruit quality (expressed in terms of ASVAB scores) by itself cannot provide a specific set of enlistment standards (or quality mix recommendation). For that, it is necessary to consider the effects of alternative enlistment standards on personnel costs as well as performance. Accordingly, the second stage of the Job Performance Measurement Project (1990 – 93) was devoted to development of what became known as the Accession Quality Cost / Performance Trade-off Model (Smith and Hogan, 1994; Black, 1988). The objective of this optimization model is to determine that accession quality mix which minimizes personnel costs while meeting performance and strength / quality goals. Since accession mix is described by AFQT category and occupation groups, the model is effectively choosing macro enlistment standards consistent with given performance goals. Personnel costs include recruiting, training, and related costs. Performance goals by occupation group are "set by expert judgment", due to the difficulty of specifying performance / capability requirements.[5] Strength goals by occupation group ensure that the results are consistent with existing strength management targets, and quality goals by occupation group represent distributional minimums to ensure proper balance across occupations. With this model DoD and the Services have a prototype planning tool for determining accession quality requirements, for use in justifying increases / decreases in accession quality as military requirements change.

---

[4] See Zook (1996) for a summary of Project A research objectives and findings.

[5] See Smith and Hogan (1994), p. 113. The authors "recommend starting with the calculated performance of a cohort that is generally viewed as having achieved satisfactory performance levels and then making adjustments based on anticipated changes in force structure and performance requirements by occupation group."

In parallel to these research projects -- job performance measurement, ASVAB validation, and cost/performance tradeoff model development – which can be described as focused on applicant standards and selection, the Services were also examining the efficacy of their applicant classification procedures. These are the personnel allocation systems, responsible for assigning new recruits to initial entry training and first military jobs. This line of research was undertaken with the belief (later proven) that the allocation system (which utilizes occupational enlistment standards) may be as important as the enlistment standards themselves in determining the predicted performance of new soldiers and hence effective quality of the accession cohort. In the Army this classification research was known as ARI Project B, and led to the development over the 1982-89 period of a research prototype Enlisted Personnel Allocation System (Research-EPAS).[6] In brief, the EPAS model is an applicant-level classification tool. It is an optimization model with the objective of determining that allocation of recruits to initial job training which maximizes predicted performance of the accession cohort, while meeting a variety of training management constraints, including occupational quality requirements. It takes overall quality, in the form of supply forecasts, as a given.

In an operational setting, the application of a classification model (such as EPAS) would naturally follow the application of a cost-performance tradeoff model. The latter model is designed for macro-level policy analysis. Its output provides least-cost quality mix recommendations by occupation group, but does not reflect performance differences within AFQT categories. When the output is aggregated, it provides guidance for overall recruiting quality goals. We envision a policy-making scenario in which the cost-performance tradeoff model is run to determine overall recruit quality and occupational quality goals. The overall recruit quality goal is used by the Directorate of Military Personnel Management to guide U.S. Army Recruiting Command (USAREC) recruiting efforts, and the quality mix recommendations that come from the cost-performance tradeoff model are used in establishing the Army Annual MOS Program and setting up the occupational quality constraints in EPAS. In this way, the optimized classification performed by EPAS – using detailed information on individual performance differences -- would occur on top of least-cost quality goals established through cost-performance tradeoff analysis.

Preview of the Discussion[7]

Following this introductory section, the second section begins with a discussion of the development of PC-EPAS as a two-stage process designed to enhance REQUEST. The discussion focuses on the optimization model engine and its accompanying post-processor that produces optimal guidance for "main" REQUEST. The model's functionality is first described in general terms, progressing into greater detail. An even more detailed description of the model is

---

[6] ARI Project B research was jointly undertaken by ARI Manpower and Personnel Research Laboratory and General Research Corporation scientists. See Konieczny et al. (1990). Project B resulted in the design, development, and testing of a full-scale research prototype Enlisted Personnel Allocation System. The Research-EPAS model was mainframe based and utilized a network optimization algorithm. The testing undertaken focused on estimation of achievable performance gains using AA composites as well as approximations to predicted performance composites. This research and model development was the direct antecedent of the PC-EPAS project to which we turn in the next section.

[7] This paper is an expanded and more readable version of the EPAS Functional Description document. See Greenston , Walker, Mower, McWhite, Donaldson, Lightfoot, Diaz, Rudnik. (1998).

found in Appendix E. Model data inputs are described in Appendix D, with MOS clusters and applicant supply groups described in Appendices B and C.

In the third section, on the costs and benefits of EPAS, suggest that optimized classification can lead to substantial increases in soldier performance through better matching of recruits into job training opportunities. Estimated benefits are compared to cost estimates for implementing and maintaining PC-EPAS, and the result is quite favorable. A larger body of classification research testing is reviewed in Appendix G.

The fourth (very brief) section highlights the utility of PC-EPAS as a planning and policy analysis tool. This use would complement its operational function.

The fifth section deals with operational design issues. As such it picks up from the second section, and begins with a discussion of the EPAS-REQUEST interface design -- how REQUEST uses the optimal guidance and how it can best support EPAS. Additional detail is found in Appendix F. A second issue concerns the need created by the enhancement for additional coordination among Army agencies involved in recruiting and training management. The third topic addressed is the objectives and approach to the field test. The section concludes with a look toward second-generation EPAS and the utilization of improved ASVAB composites and classification-efficient job families (see Appendix H).

Development of PC-EPAS

Introduction

The Army's Recruiting Quota System, known as REQUEST, assigns applicants to initial entry training based on current job-fill requirements and requires that they meet MOS minimum qualifications. REQUEST does not attempt to assign would-be recruits into jobs for which they would be most productive. It does not discriminate among applicants who range from least to most qualified for a given type of training. In addition, applicants are treated and assigned one at a time (sequentially), failing to exploit possibilities for better matches by choosing from among a pool of applicants for a given training opportunity. Existing classification procedures virtually ignore differential abilities and the dynamic aspect of allocation.

EPAS is designed to enhance REQUEST by introducing optimization into what is a sequential assignment process. This is done by viewing the assignment process as two phases. In the first phase, a large model represents the monthly flow of applicants and availability of training class seats over the recruiting year. Applicants are categorized into supply groups by their demographics and aptitude profiles. The model is solved to determine the optimal allocation or matching of (applicant) supply groups to MOS training opportunities. The optimal allocation is the one that maximizes predicted performance for the entire recruit cohort, while meeting accession and training management goals. (Note that the better the match between applicant aptitudes and MOS skill requirements, the higher the predicted performance.) The model solution is updated weekly and used to generate an ordered list of MOS training recommendations particular to each supply group. In the second phase, that of actual applicant assignment, these recommendations are merged with those generated by existing REQUEST procedures and presented to the applicant by the career counselor.

Overview of EPAS Procedures

The requirement for EPAS is to develop a methodology that can apply the advantages of optimization to an inherently sequential classification process. Figure 2-1 depicts the proposed EPAS functionality as designed to enhance REQUEST. The proposed enhancement has three major components. They are described in general terms below, and in more detail in the attached appendices.

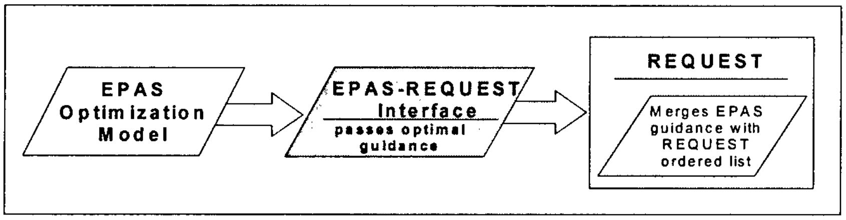


Figure 2-1. EPAS Proposed Functionality

Solve an aggregate allocation optimization model that represents the monthly flow of applicants, manpower requirements, and the availability of training class seats over the recruiting business cycle. The EPAS engine is a large optimization model that is solved using a linear programming algorithm. The model is solved for that allocation of applicant supply to training opportunities that maximizes recruit predicted performance while meeting accession and training management goals. The model consists of approximately 3,000 equations (i.e., accession / training management constraints) and 200,000 variables (i.e., possible allocations). The optimization model requires input data that represents the supply of applicants and the demand for trained recruits:

a. Applicant Supply Forecasts. Supply data refers to the flow of applicants signing enlistment contracts. Because the future flow of applicants to Army recruiting stations is unknown, the model requires a forecast of the supply of applicants. EPAS derives a 12-month forecast of monthly enlistment contracts, by number and type of applicant, from U.S. Army Recruiting Command (USAREC) mission forecasts and uses this to represent the "supply" side of the optimization model.

b. MOS Accession Requirements/Training Seats. Demand data consists of (1) monthly accession targets (all MOS and missioned MOS), (2) MOS annual training requirements, and (3) MOS training class seat availability. The ODCSPER Accession Division develops a recruiting mission statement, consisting of annual and monthly accession requirements, monthly missioned MOS requirements, and quality marks. U.S. Army Training and Doctrine Command (TRADOC) establishes a schedule of school training seats by MOS and date. This schedule is managed within the Army Training Requirements and Resources System (ATRRS). PERSCOM Accession Management Branch (AMB) manages seat availability and quotas for each MOS. Start dates, MOS entry restrictions, and quality goals are associated with each class.

Figure 2-2 illustrates data preparation and the optimization process (identifying more detail of the "EPAS Optimization Model" block in Figure 2-1). The optimal solution of the linear programming model identifies the best MOS training opportunities for each applicant type.

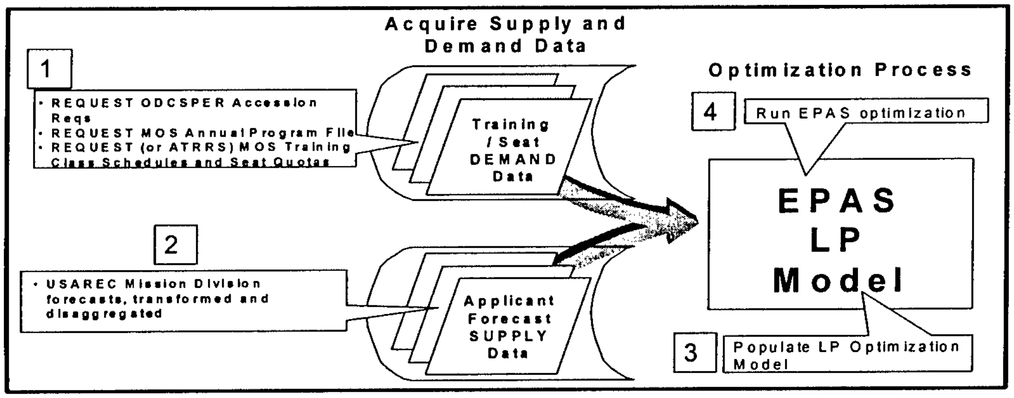


Figure 2-2 EPAS Optimization Functionality

Compute EPAS optimal guidance (EOG) using optimization model outputs and export the EOG to REQUEST through interface mechanisms (depicted as the middle block in Figure 2-1). Following optimization, reduced costs are calculated from solution outputs. These are used to rank-order near-optimal allocations. Both optimal and near-optimal allocations are used in building the EPAS optimal guidance (EOG). The interface function is to build the EOG ordered lists from the EPAS optimization output and communicate this data to REQUEST during the REQUEST update cycle.

Merge EOG and REQUEST ordered lists to produce the MOS class choices presented on the career counselor's screen for the applicant's consideration (depicted as the right block in Figure 2-1, and illustrated in Figure 2-3). The merge of EOG and REQUEST ordered lists becomes the EPAS-enhanced ordered list presented on the career counselor's terminal. In the merge process, those training recommendations found in both EOG and REQUEST lists are placed on the enhanced list in EOG order. REQUEST training recommendations that are not on the EOG can be added to the bottom of the new ordered list. In this way the merge rule allows the EOG to control the order while utilizing the screening functions played by REQUEST using more detailed information on applicant characteristics and training opportunities.

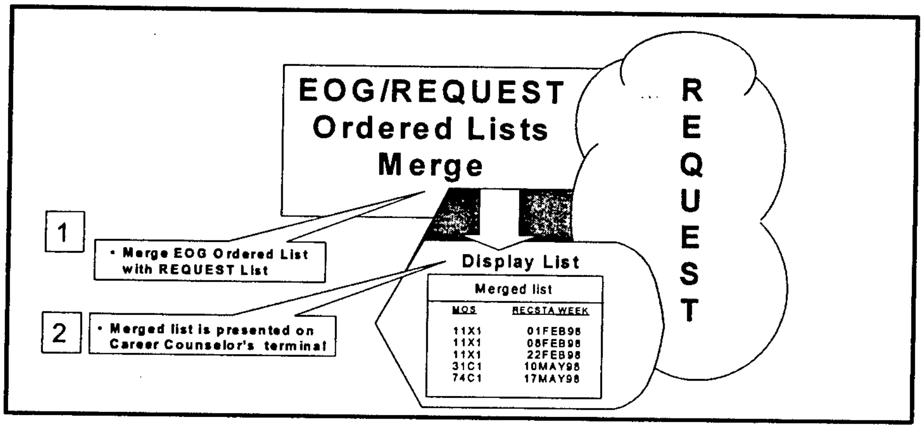


Figure 2-3 Merge Functionality

It is worth emphasizing that operationally this is a two-phase procedure. In the first phase, occurring once a week (or more frequently if needed), the optimization model is solved and the EOG for each applicant type is generated. The second phase is carried out in real time as the applicant meets with the career counselor: "behind" the career counselor's screen EOG and REQUEST lists are merged to generate a customized list for the applicant.

It is anticipated that EPAS will be run in accordance with normal weekly REQUEST update cycles. At the end of each recruiting station week, AMB will run EPAS. At this time, data obtained from REQUEST will update EPAS with current class seats that have been filled and any other modifications to training seats or requirements. EPAS will use updated applicant forecasts, requirements, and seats as inputs in a new optimization model run.

Description of the Aggregate Allocation Model and EPAS Optimal Guidance

Gross vs. net model. The Delayed Entry Program (DEP) allows contractees to delay accession and initial entry training. This is a crucial feature that is exploited by the optimization model (see below). During the DEP period, some individuals drop out and in effect cancel their enlistment contracts. The aggregate allocation model is what might be called a "gross" level model because it accounts for all those who sign enlistment contracts (so-called gross contracts), including those who drop out of the DEP. In a corresponding fashion, accession / training requirements and training seats are inflated to account for expected DEP losses. Thus, the objects of the model – applicants or contractees (see below), accession and training requirements, and training seats – are all expressed in "gross" terms.

"Applicant" supply group forecasts. The supply side of the model is represented by forecasts of applicants signing enlistment contracts (contractees).[8] USAREC prepares forecasts of monthly net contract production required to make mission.[9] These forecasts extend 12 months into the future, and are updated on a quarterly basis. Forecasts are made for the three mission categories: GA (high school graduate, Test Score Category 1-3A (hereafter TSC 1-3A), SR (high school seniors), OTHER (all others). As part of EPAS model data input procedures, these net contract forecasts are inflated by expected DEP losses in order to obtain a forecast of gross contracts. The three mission categories are disaggregated into thirteen demographic groups based on sex, education, and AFQT category.[10]

Forecasts for each of the demographic groups are prorated among their corresponding supply groups according to average historical shares. Supply groups (SG) are empirically determined clusters of individuals having similar AA composite scores within each of the demographic groups. In other words, the supply groups represent types of contractees: each cluster is defined by its demographic characteristics and its average AA composite scores. These are the essential classification characteristics utilized by the model. Cluster analysis conducted for the first generation EPAS model identified 150 supply groups (127 active supply groups); their distribution by demographic group are shown in the table below.[11] To illustrate the supply group concept, consider supply group no. 3, which belongs to the male, high school graduate, TSC 1-3A demographic group. Its average AA composite scores are GM, 111; EL, 108; CL, 107; MM, 115; SC, 112; CO, 113; FA, 118; OF, 115; ST, 118.[12]

---

[8] The model is classifying expected contractees (individuals who sign enlistment contracts), and does not account for applicants who choose not to enlist.

[9] Monthly net contract production equal the difference between the number of applicants signing contracts during the month (i.e., gross contracts) and the number of DEP losses occurring that month.

[10] These factors should be estimated with regression equations over approximately a 5 year period using monthly observations of group shares. This allows the estimation of seasonal effects and any policy effects believed to influence the composition within the three mission categories. The factors should be updated about once a year. Specification and estimation results of the regression equations in use for the prototype PC-EPAS are described in Appendix D.

[11] Supply group methodology is described in Appendix C.

[12] AA composites are named as follows: GM, general maintenance; EL, electronics; CL, clerical; MM, mechanical maintenance; SC, surveillance / communications; CO, combat; FA, field artillery; OF, operators / food; ST, skilled technical.

Demographic Group	Number of Supply Groups
Male, high school graduate, 1-3A	26
Male, high school senior, 1-3A	16
Female, high school graduate, 1-3A	12
Female, high school senior, 1-3A	8
Male, high school graduate, 3B	14
Male, high school senior, 3B	9
Female, high school graduate, 3B	8
Female, high school senior, 3B	7
Male, non-graduate, 1-3A	8
Female, non-graduate, 1-3A	5
Male, non-graduate, 3B	4
Female, non-graduate, 3B	3
Male, high school graduate, 4	7

MOS clusters. The clustering of MOS for use in the aggregate allocation model is straightforward because each MOS belongs to a job family defined by the primary aptitude area (AA) composite used in determining eligibility for training. Thus, clusters are defined by the nine job families, the minimum AA score required for training, and any gender, education, and mental category restrictions. An illustration will clarify the clustering scheme. Cluster 33 contains 45N (M60A1 tank turret mechanic) and 63N (M60 tank systems mechanic). It is defined by the mechanical maintenance (MM) aptitude area composite, cut score of 100, high school graduates and non-graduates allowed, males only allowed, AIT training, and non-missioned / non-critical MOS.[13] (Note that in the production version of the model MOS clusters will no longer be necessary; the model will be specified and solved using individual MOS.)

Optimization model. The optimization model is an aggregate allocation model to ensure that it is of manageable size for solving. This is achieved with the use of supply groups and MOS clusters (described above). The model depicts the recruit training management environment at a given point during the recruiting business cycle. Given the Delayed Entry Program, which permits accession up to 12 months following enlistment contracting, the optimization model problem at the start of month t is to optimally allocate the supply group flow into training classes. Supply group flow is described by SG i (i = 1,...150) expected to contract in month j (j = t,....12). The training classes are described by training in MOS cluster m (m = 1, ...65) starting in month k (j+12 ≥ k ≥ j). The objective function of the model is to maximize total recruit predicted performance. The optimal allocation is that which maximizes recruit predicted performance while satisfying the accession / training management constraints describing the environment.

---

[13] MOS clusters are described in Appendix B. In addition to the categorization rules mentioned, it is also necessary to distinguish among MOS that can be treated differently in modeling the classification process. This means that AIT and OSUT MOS are grouped separately, and that priority and missioned MOS are grouped separately (within the larger scheme described).

In the first generation EPAS model, predicted performance was approximated by the AA composite score for the job family to which the individual has been allocated. Project A research has shown a tenuous relationship between AA composite scores and soldier performance, but a relatively robust relationship between the (underlying) ASVAB test scores and performance. The second generation EPAS model utilizes new predicted performance (PP) metrics and associated job family structures, developed in research sponsored by ARI. The new metrics are based on properly weighting ASVAB test scores so as to form PP composites.

Recruiting business practice is focused on achieving the accession mission and quality goals of the current fiscal year (FY).[14] The model constraint set consists of feasibility, production, and quality target constraints. So-called feasibility constraints define the allowable connections between supply groups and MOS clusters. In the first place, a connection between SG i and MOS cluster m is allowed only if the supply group's average AA score on the composite which defines that MOS cluster exceeds the minimum (or cut) score required for training. Second, connections between SG i and MOS cluster m are allowed only if gender-education-AFQT restrictions are obeyed. Third, the allowable connections between SG (i,j) and MOS cluster (m,k) are governed by user-imposed limits on the allowable length of the DEP period.[15]

Turn now to the production constraints. First, all supply must be allocated. The algorithm is not permitted to leave supply unused in its quest to maximize the objective function. Second, allocations cannot exceed available class seats. Third, allocations must meet (or exceed) monthly total accession requirements, and allocations must meet (or exceed) monthly missioned MOS accession requirements.[16] These constraints refer to the current FY. Fourth, allocations cannot exceed annual MOS training requirements for the current and next FY.[17]

Quality targets are represented in the model with the following constraints. Allocations cannot exceed the annual MOS training requirement TSC 3B & 4 targets or limits (or alternatively, allocations must meet or exceed the annual MOS training requirement TSC 1-3A targets). Allocations cannot exceed the annual total training requirement TSC 4 target or limit.[18]

Building the EPAS optimal guidance (EOG). The solution to the aggregate optimization problem is described by the solution matrix, BT(i,j,m,k). This contains the optimal allocation for supply group i, contracting in month j, for training in MOS cluster m, starting in month k. Since actual applicants may not accept the MOS class recommendation from the supply group's optimal solution, each supply group must also have a sequence of near-optimal MOS classes to facilitate applicant choice.

---

[14] In fact, we do more than this in the prototype formulation. The model utilizes only current year supply --- the cycle starts out with a 12 month supply horizon and becomes increasingly myopic over the year. This means that (forecasted) supply beyond the current FY cannot affect the aggregate allocation solution. In principle, we can relax this without harming the current FY focus, though there may be some boundary concerns about AIT v. OSUT.

[15] In the prototype model, allowable DEP length can be varied according to AFQT category of the supply group. For seniors, there is a default of up to 12 months.

[16] Some experimentation is underway to examine the efficacy of variants of the missioned MOS constraints.

[17] Accession requirements refer to start of basic training or OSUT training. Training requirements refer to start of AIT or OSUT. Thus, an allocation toward the end of the year to a BT/AIT MOS could count toward meeting the current FY accession requirement but not the training requirement if the AIT start is in the next FY.

[18] MOS gender and high school graduate balance targets do not appear to warrant separate constraints.

These near-optimal MOS class lists are created with the reduced costs associated with the optimal solution, and represent a sequence of next best, next next best, etc., MOS cluster classes. Reduced costs represent the change in the objective function that would result from increasing a particular supply group's flow to one MOS cluster class while reducing its flow to another. All variables (i.e., allocations) in the optimal solution have zero reduced costs. Reduced costs for the remaining variables have zero or negative values.[19] Starting from the optimal solution, all possible flows of current (period) contractee supply groups can be ordered by the absolute values of their corresponding reduced costs.[20] The result is each supply group's MOS cluster class list in decreasing order of optimality – that is, each supply group's ordered-list of MOS cluster class allocations.

In the next step, each current supply group's ordered list of MOS cluster classes is disaggregated to individual MOS class with MOS class availability verified. MOS classes in the same cluster are placed in reverse order of their MOS current percentage fill. This constitutes the EOG that is forwarded to REQUEST.[21]

---

[19] Exceptions are alternate optima and degenerate solution variables, which have zero value and zero reduced costs.

[20] Refers to feasible flows.

[21] Other MOS class ordering criteria could place MOS in order of the number or percentage of unfilled class seats.

Cost-Benefit Analysis of Optimized Classification

Benefit Estimation[22]

Introduction. The model formulation has been evolving, and we now describe results from the testing of a revised PC-EPAS prototype. The revised model better resembles current recruiting practice with its focus on the current fiscal year. The revised prototype approximates a variable length recruiting business window formulation, in which the planning horizon in late spring or early summer begins to include next fiscal year's training requirements and class seats.[23] It has been tested with "independent" supply and demand data for 1997-98. USAREC FY 1997 contract forecasts and 1997 individual recruit characteristics data were used on the supply side, FY 1997-98 training requirements were taken from the Seabrook report, and 1997-98 training seat data came from Army Training Requirements & Resources System.[24]

In the current version of the model, the planning horizon encompasses the first fiscal year (FY1). The allocations are constrained to meet FY1 monthly total accession requirements and monthly missioned MOS accession requirements, and are constrained not to exceed FY1 and FY2 MOS training requirements.[25] In effect, the model focuses on filling FY1 requirements and AIT training requirements for October and November of FY2. MOS quality requirements take the form of TSC 3B-4 limits, while separate MOS female targets do not appear to be needed and are not included. There are 127 active supply groups and 65 MOS clusters. Allowable connections between supply groups and MOS clusters obey gender, education, and cut-score restrictions.

Performance improvement: simulation of PC-EPAS prototype. In the simulation mode, the linear programming model is first solved for the aggregate allocation over the planning horizon and the corresponding EOG for month one (i.e., the current month) applicants. Using this guidance, the assignment of individual applicants contracting in the current month is simulated. After the simulation, the current month is advanced and the cycle is repeated. In this way a 12-month simulation is run.

---

[22] In Appendix G, we review model development and results of several Army classification research projects. We begin with the ARI Project B study (also referred to as Research-EPAS), and consider the research by Nord and Schmitz (1989) in the 1980's; that by Zeidner, Johnson, and Statman (1993) at George Washington University in the 1990's; that going on at the Air Force Human Resources Laboratory in the 1990's; and that comprising the current PC-EPAS project at ARI (1993 to present).

[23] The current versions are the EPASSIM.BT1 (see Appendix E) and BT11/12 formulations. The early prototype included several artificial variables necessitated by the inclusion of FY1 and FY2 requirements over a fixed, 24-month horizon. In the revised prototype, only FY1 requirements are enforced and artificial variables are not used.

[24] The procedures followed to develop and align the data are described in Appendix G. The alignment procedures generated a planning mode data set with 78,809 requirements for the first fiscal year (known as FY1); of these, 31,369 were filled by applicants contracting in the previous year, leaving an unfilled FY1 requirement of 47,440.

[25] In the BT12 formulation, monthly missioned MOS are summed and treated as a single group each month, and the missioned MOS are constrained to meet FY1 annual training requirements. This variant is employed in order to overcome data alignment problems.

For each applicant the simulation procedure calls for the first 25 job assignment choices to be taken directly from the EOG.[26] The applicant is simulated to begin selection from the recommended EOG opportunities in three alternate ways: (a) taking the training opportunity at the top of the list; (b) selecting randomly from the top 5 on the list; and (c) selecting randomly from the first 25 on the list. Obviously, the "top of the list" procedure represents close adherence to EPAS guidance and, as such, an upper bound to the performance gain that is likely to obtain in an operational setting. In presenting the assignment choices, we ignore timing-of-accession preferences that the applicant or the Army may have as expressed by the DOA window; however, in solving the aggregate allocation problem we do set allowable training delays (i.e., maximum DEP lengths) and these are reflected in the EOG utilized by the simulation.

In conducting the simulation procedure as described, we test the adequacy of the EOG to meet FY1 accession and training requirements while maximizing performance. This is a rigorous test because the only connection between the aggregate allocation model (i.e., the production mode engine) and the simulated training assignments is the EOG. In other words, we are running an unconstrained simulation vis-à-vis FY accession and training requirements.

Table 2 below depicts the simulation results.[27] Simulations using the EOG are compared to REQUEST mode simulations. In the latter, the applicant selects from a list of job assignments, ordered by training class start date (starting from soonest), for which he/she is eligible. The performance improvement obtained for applicants assigned to either FY1 or FY2 training – the difference between EOG and pseudo-REQUEST mode simulations – was 3.9 AA points for top-of-the-list selection, 3.6 AA points for top 5, and 3.0 AA points for top 25. These results are striking and strengthen the case for optimizing job-person match because the classification management process as modeled here is considerably more realistic than previous research. Departing from the EOG, as illustrated by random selection from top 25, leads to a loss of about one AA point in performance and a noticeable drop in fill rates.

Valuation of performance improvement. The value of the EPAS performance gains can be estimated as the opportunity cost of retaining the current system. In the present context, this is the additional cost of using current assignment procedures to achieve the same level of performance gains obtainable through optimization procedures. Specifically, using current assignment procedures, how many additional 1-3A recruits, in place of 3B recruits, would be required to achieve the same gains obtained through PC-EPAS(AA), and what would it cost to acquire them?

---

[26] If selection cannot be made from this set, it is followed by opportunities taken from the larger set of ATRRS seats available for which the applicant qualifies.

[27] A total of 79,372 FY 1997 applicants were simulated. The results described refer to simulation with the BT1 version of the prototype.

The LP optimization that generates the EOG was set to allow training delays (i.e., DEP lengths) of 6, 4, and 2 months for TSC 1-3A, 3B, and 4, respectively; seniors can DEP out up to 12 months, but not beyond the following summer (except for rising seniors).

Table 2. PC-EPAS Simulation Mode Testing: 1997-98 data, AA metric

	Average AA Score (FY1 & FY2)	Fill Percentage (FY1)
1. Current (approximation to REQUEST[28])		
-- Top of list	106.9	94
-- Random selection from top 5	107.0	96
-- Random selection from top 25	107.0	94
2. Constrained optimization		
2a. BT1 model -- 9 families/unit weighted composite (65 clusters)		
-- Top of list	110.8	87
-- Random selection from top 5	110.6	84
-- Random selection from top 25	110.0	76

The heart of the opportunity cost calculation is determination of the number of additional 1-3A recruits required. The 1997 accession cohort baseline (i.e., the assignments made using the current procedures) is ordered from high to low by AFQT score. For individuals at each percentile score, average and cumulative average predicted performance scores for the job assignments actually made are calculated. To meet a predetermined overall average performance target, individuals from the bottom are successively deleted and replaced with 1-3A recruits (assumed to score at the original 1-3A average) until the performance target is reached.

Calculations are made for cohort size of 72,000, with 1-3A recruits comprising about 68%. Average recruiting costs are $11,660 for high-quality and $6,223 for low-quality recruits. Marginal costs are estimated at $35,555 for high-quality recruits, and assumed to increase with high-quality share (each one percent increase in share is associated with a one percent increase in marginal costs). For example, at 80% high-quality share, the average cost has increased to $14,935 for high-quality recruits. Recruiting costs refer to 1995 (Source: USACEAC Army Manpower Cost System).

The opportunity cost estimates of the 1997 simulation mode results are shown in Table 3 above. Opportunity costs are calculated for the three procedures of simulating training selection from the ordered list. The costs of achieving the same level of performance improvement from the current system (as have been achieved through EPAS optimization) range from $159M to $272M per year!

---

[28] For FY 1997 accessions, the average AA score of actual assignments made by REQUEST is 108.5.

Table 3. PC-EPAS Benefit Estimation: Simulation Mode, AA Metric, 1997-98 Data

	AA Improvement	Additional 1-3A Required	Required Percentage 1-3A	Opportunity Cost ($ million)
1. Current (approximation to REQUEST)	.000	0	68	0
2. Constrained optimization				
2a. 9 families/unit weighted composite				
-- Top of list	3.9	8,461	84	272
-- Random selection from top 5	3.6	7,328	82	233
-- Random selection from top 25	3.0	5,129	78	159

Cost estimation: EPAS implementation and maintenance

It is estimated that the EPAS development cycle, to include software development, testing, fielding, and the initial evaluation of the production mode implementation results, will require approximately one year. The presumption is that Production-EPAS will be developed using contractor resources. First year development costs are estimated between $450K and $600K, and second year costs are estimated between $200K and $225K. Subsequent – maintenance mode -- annual costs are estimated at $130K, but could be as low as $75K if EPAS is built and maintained by the REQUEST contractor.

Net utility of EPAS

The dollar benefit value of the predicted performance (using the AA metric) improvement dwarfs the estimated cost, under all the assumptions of simulated applicant selection from the ordered list. Furthermore, ARI-sponsored research nearing completion suggests that the use of PP composites (a better performance metric) produces even larger gains in predicted performance (see Zeidner, Johnson, Vladimirsky, and Weldon, 2000). Finally, the utilization of research into improved measures of soldier performance and better classification methods is not possible without automated, sophisticated optimization procedures such as EPAS.

PC-EPAS Planning and Policy Analysis Capability

PC-EPAS can be utilized to conduct planning and policy analysis in two modes. In the planning mode, we adopt an aggregate level of analysis and the focus is upon the aggregate allocation model and the corresponding linear programming solution. In this mode we examine the effects of applicant supply / training demand and policy changes over a twelve month (planning) horizon, but we abstract from the interactions that occur among them throughout the year, and from the particulars of job training selection by individual applicants.[29]

PC-EPAS can also be utilized to conduct policy analysis through simulation of the classification process at greater fidelity. This is called its simulation mode because the flow and job training selection of individual applicants is simulated. In this mode, the aggregate allocation model is solved over the planning horizon, reduced costs and the EOG are computed for current period contractees, and the EOG is used (either by itself or merged with a proxy REQUEST list) to create an ordered list from which individual applicants are simulated to make their job training selections. Following the selections, the period is advanced one month, and the solving-simulation cycle begins again. The benefit estimation results described in the previous section were based on simulation mode runs, while the results of planning mode runs have been described in earlier reports (Rudnik and Greenston, 1996).

PC-EPAS facilitates planning and policy analysis because it brings together many of the accession and training management elements into a modeling framework. These elements are monthly contractee supply, missioned quantity and desired quality; accession and training requirements, including monthly total and missioned MOS accession goals, annual MOS training program goals, and total quality marks and MOS quality goals; training eligibility standards; and scheduled school training seats. Within this framework, the analyst can examine the effects of changes in these elements upon the feasibility of meeting requirements, the Delayed Enlistment Program (DEP) structure, and predicted performance. (DEP allows individual to intersperse a delay between contracting and accessioning.) Several examples will illustrate the variety of analyses that can be conducted.

Example one: Suppose a decision is made to increase the TSC 3B share of new recruits. Under classification optimization, we have shown that the adverse impact can be mitigated. By how much? What is the best way to distribute the reduced quality across MOS? Will a change in MOS quality goals be necessitated? If the reduction in quality means a change in monthly contractee flows, will a change in school schedule be necessary?

Example two: Suppose a decision is made to increase the female share of new recruits. Given the existing MOS gender restrictions, what is the impact upon the feasibility of meeting training requirements? Would average DEP lengths increase? Under classification optimization, which MOS would experience greater female participation?

Example three: Suppose the share of females in traditionally female occupations is capped at 20 percent. Under classification optimization, to which MOS would the "displaced"

---

[29] Note that the LP solution of the aggregate allocation model, extended by computation of reduced costs and the EPAS optimal guidance for current month contractees, forms the core of the EPAS operational engine.

females tend to migrate? Which demographic groups would tend to take their place in the "capped" occupations? Would predicted performance be affected?

Example four: Suppose there is a shift in scheduled school seats from winter to summer months, or vice-versa. What is the impact upon the feasibility of meeting training requirements? What would be the likely impact upon average DEP length? Would predicted performance be affected?

Example five: Suppose missioned MOS requirements are changed -- either existing ones are changed or monthly missions are imposed on new MOS. What is the impact upon the feasibility of meeting requirements? Are there noticeable impacts on other MOS?

The implementation of a planning and policy analysis capability in the planning mode as part of operational EPAS would be straightforward. The capability is comprised of changing the supply/demand inputs or parameters or constraints, etc. and solving the aggregate allocation model, and reporting the impacts. Implementing the capability in the simulation mode as part of operational EPAS would be more complicated. In such an endeavor the lessons learned from the simulation capability of the PC-EPAS prototype should prove useful.

Design Considerations of the Operational Model

In this section we discuss a variety of issues affecting the proposed operational model. The first topic deals with merging the EPAS optimal guidance (EOG) and the REQUEST list to create optimized recommendations for the individual applicant. This discussion picks up from the second section, which finished with a description of how the EOG is created, and as such continues the interface design discussion. Second, we address the most obvious coordination issues that will arise among the Army agencies responsible for recruiting and training management. Third, we discuss the objectives and research approach to the proposed field test. Fourth, in Appendix H, we discuss the steps in moving toward a second generation EPAS using new performance composites.

Interface Between EPAS And REQUEST

How Army Recruiting Uses REQUEST

Recruit processing. REQUEST, the Army's training reservation system, functions much like an airline or hotel booking system. Processing an Army recruit applicant includes interviews and aptitude testing followed by a physical examination at a military entrance processing station (MEPS). The applicant next visits a career counselor who uses REQUEST to recommend an available MOS with associated reception station (hereafter RECSTA)[30] training class start weeks.

Date-of-Availability (DOA) window. Among classification information such as gender, qualifications, and graduation status, career counselors and applicants determine a mutually agreeable time when the applicant would like to start training. This is known as the DOA window. This process assures an applicant's potential acceptance of REQUEST's (up to) 25 MOS.

Factors affecting the sequence of MOS classes from REQUEST Search Mode. Either before applicants arrive, or in their presence, career counselors operate the REQUEST Search Mode. They create, internal to REQUEST, a file of all potentially available MOS class start weeks within the applicant's DOA. This file includes only the MOS for which the applicant is qualified[31], meets distribution of quality[32] (DQ) targets, and satisfies Report / Update DEP (hereafter RUDEP)[33] controls. After considering the above factors, REQUEST forces high-priority MOS to the top of the career counselor's classification screens.[34] The Search Mode then displays the applicant's 25 highest scoring MOS class dates in groups of five.

---

[30] The training start and RECSTA weeks for OSUT MOS are nearly the same, but AIT MOS differ by the 2-month BT length. Since REQUEST indexes OSUT and AIT classes by RECSTA week as well as training start-week, EPAS indexes MOS training classes by their RECSTA date to simplify its optimization model formulation.

[31] ASVAB scores, drivers license, color vision, etc.

[32] MOS training always accepts AFQT I-IIIA applicants, but may limit AFQT IIIB and IV applicants depending on MOS current fill and DQ targets.

[33] Based on AFQT and HS graduation status, RUDEP restricts DEP length and access to groups of MOS.

[34] At this point the EOG would affect the REQUEST MOS recommendations.

Design for REQUEST Modifications

When the applicant's demographic data and test scores are available, REQUEST selects the EOG vector of MOS RECSTA months corresponding to the applicant's supply group. Transparent to the CC and applicant, the EOG for the applicant's supply group is merged with REQUEST's ordered MOS list. The applicant now may select among MOS classes that were essentially individually optimized for him or her.

Determining candidate's supply group. REQUEST will parse candidate's characteristics to determine his/her EPAS supply group and corresponding EOG. Their supply groups determine their appropriate sequence of MOS RECSTA months for optimal assignments. With this information, the candidate's applicable EOG is selected. This process is detailed below.

Given applicant's demographic category (defined by gender, education, AFQT category), his/her AA composite scores are compared with the set of supply group AA profiles corresponding to the given demographic category. The sum of squared differences between the applicant AA profile and the applicable sets are calculated, and the applicant is identified with that supply group for which the sum is smallest. For example, if the applicant belongs to the male, HSDG, 1-3A demographic category, his AA composite scores would be compared with the AA profiles for supply groups 1 – 26 (see Appendix C), and the supply group found to most closely match (according to the calculation) becomes the appropriate one.

Merging the EOG with REQUEST ordered list. The EOG's MOS class status lacks the REQUEST list's timeliness (in terms of MOS class information) and DOA considerations, and does not reflect detailed applicant characteristics (e.g., reduced color vision). In the merge process, those training recommendations found in both EOG and REQUEST lists are placed on the enhanced list in EOG order. Merging lets the EOG control the order while retaining all the REQUEST information.[35]

---

[35] The EOG and REQUEST ordered lists are merged using the following six steps (see Figure 5-1 for a sample merged list illustration):

1. Initialize the EOG array element pointer to 1 and the Merged List (output) array pointer to 0. The Merged List array is initially empty. In the REQUEST ordered list array, add a "used" data item and initialize this to "no" for every array element.
2. "Visit" (retrieve) the next MOS-month array element on the EOG. If at the end of the EOG array, go to step 6. Search the REQUEST list (in order, 1 to n) for a matching MOS. If no match is found, go to step 5.
3. MOS match – let's see if the class months match. Do a year-month comparison of the EOG class month to the REQUEST class date. If they don't match, go to step 4. If they do match, increment the Merged List array pointer and insert the current REQUEST ordered list element into the Merged List array. Mark the "used" data item for the current element in the REQUEST ordered list as "true."
4. From the current position on the REQUEST ordered list, search further on the list for a matching MOS. If found, go to step 3; else, go to step 5.
5. Increment the EOG array pointer and go to step 2.
6. The EOG array has been completely processed; now, add all remaining items on the REQUEST ordered list array to the Merged List array. "Visit" each array element on the REQUEST order list (in order 1 to n). Check the "used" data item. If "used" is no, add this item to the Merged List array by incrementing the Merged List array pointer and inserting the current REQUEST ordered list element into the Merged List array element. Iterate this process through each array element of the REQUEST ordered list until done.

Steps 1 through 5 effectively restricts the EOG to specific MOS classes with current vacancies. Step 6 will let the applicant see available MOS classes even though they are not in the EOG.

The merging process retains the best of REQUEST and EPAS. The EOG does not screen an applicant's potential MOS training for the detailed qualifications[36] that REQUEST enforces. However the EOG does include functionality similar to that performed by DQ, RUDEP, and MOS priority. Because these controls are also implemented through the EOG planning horizon as well as through REQUEST's deterministic methods, REQUEST should be made to ease[37] controls that are redundant to the EOG.

Modifying USAREC/REQUEST Procedures to Support EPAS

EPAS is designed to provide optimized guidance to REQUEST in the assignment process. It works in the realm of recommendations, whereas REQUEST is a training reservation system that works with actual assignments. Thus, the burden is upon REQUEST to monitor and control the actual flow of assignments, and to do it in a way that permits the benefits of optimized guidance to be realized. In this section we discuss two REQUEST procedures that USAREC employs: the Distribute Quality (DQ) and Report/Update Delayed Entry Program (RUDEP) functions.[38]

The distribute quality (hereafter DQ) function. Annual MOS quality (i.e., mental categories) targets and MOS education requirements are represented in the EPAS aggregate allocation model and incorporated into the EOG. This does not guarantee balance in quality over the year; this is accomplished with DQ and education controls on actual assignments. These controls enable USAREC Recruit Operations (RO) to deny/allow particular person job-match combinations based on the mental category and education of the contractee and the quality/education fill of the particular job at the time of actual assignment.

The method currently used for determining the DQ status of an MOS is based on the quality percentage fill. The formula used is:

DQ status = TSC 1-3A fill percent – TSC 1-3A target percent.

When DQ status is positive, then TSC 1-3A eligibility is denied. For example, if the quality fill percent achieved is 75% and the target percent is 55%, then TSC 1-3A contractees would be denied a training opportunity in the particular MOS at the particular time. The disadvantage of this method is that a high TSC 1-3A fill percent is often characteristic of low total fill, and so following the rule would prevent additional TSC 1-3A's from entering this MOS. The advantage is that this method gives the best hedge against the ever-present possibility of a cut in the MOS's annual program.

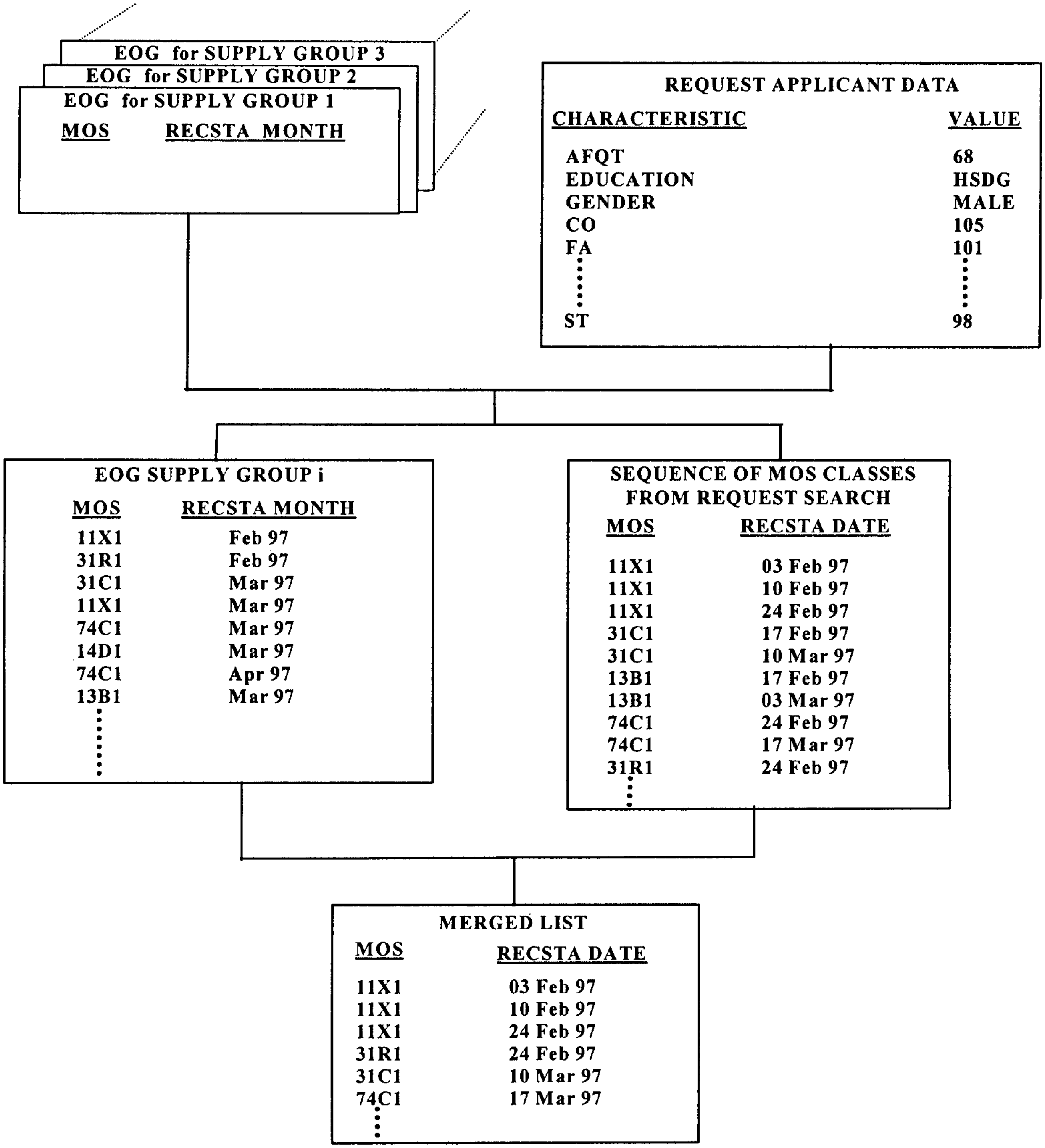
---

[36] Such as driver's license required for MOS 88M, Motor Transport Operator.

[37] Some thoughts on how this "easing" of controls should be done is described below; it is also a topic for research underway at ARI.

[38] This section draws on a report by McWhite and Greenston (1997).

Figure 5-1: Merge List Example



EOG for SUPPLY GROUP 3

EOG for SUPPLY GROUP 2

EOG for SUPPLY GROUP 1

MOS	RECSTA MONTH

REQUEST APPLICANT DATA

CHARACTERISTIC	VALUE
AFQT	68
EDUCATION	HSDG
GENDER	MALE
CO	105
FA	101
⋮	⋮
ST	98

EOG SUPPLY GROUP i

MOS	RECSTA MONTH
11X1	Feb 97
31R1	Feb 97
31C1	Mar 97
11X1	Mar 97
74C1	Mar 97
14D1	Mar 97
74C1	Apr 97
13B1	Mar 97
⋮	

SEQUENCE OF MOS CLASSES FROM REQUEST SEARCH

MOS	RECSTA DATE
11X1	03 Feb 97
11X1	10 Feb 97
11X1	24 Feb 97
31C1	17 Feb 97
31C1	10 Mar 97
13B1	17 Feb 97
13B1	03 Mar 97
74C1	24 Feb 97
74C1	17 Mar 97
31R1	24 Feb 97
⋮	

MERGED LIST

MOS	RECSTA DATE
11X1	03 Feb 97
11X1	10 Feb 97
11X1	24 Feb 97
31R1	24 Feb 97
31C1	10 Mar 97
74C1	17 Mar 97
⋮	

The introduction of EPAS procedures puts a premium on the proper management of DQ and education switch settings. If the settings are unduly restrictive, they will have the effect of disallowing certain EOG recommendations. Competition between MOS for quality should be recognized, and proper management should include these considerations: (1) If many MOS are closed to TSC 1-3As, high-quality applicants will not have a broad choice of MOS; (2) It may be necessary to risk a quality imbalance to fill seats in class-constrained MOS; (3) During the slower recruiting months, easier-to-fill MOS should be filled with quality applicants; (4) During the better recruiting months, attractive MOS should not take quality applicants away from harder-to-fill MOS.

RUDEP function. USAREC is charged with recruiting and scheduling for training that flow of potential contractees needed to achieve the Army's monthly accession and annual training requirements. A DEP process is used by all Services to allow would-be recruits to contract for enlistment with a delay until they access and begin training. The USAREC Recruiting Operations Center (hereafter ROC) uses DEP control -- the expert system RUDEP process -- to channel applicants into those accession-months and MOS that best support recruiting management. In determining allowable training assignments, RUDEP performs functions similar to those performed by EPAS. Accordingly, there is need (as with the DQ function) to ensure that RUDEP controls are not working at cross-purposes with EPAS.

The ROC controls accessions to RECSTA months. Based on the current accession status, the ROC determines target RECSTA month(s) for each MOS and type of applicant (gender, education, AFQT category). On a daily basis the ROC updates the projected accessions from previous contracts. It then determines if the currently available RECSTA month(s) provide sufficient training opportunities for the day's floor count of applicants. If not, the RECSTA months are advanced one month.[39] When RECSTA month MOS accession targets are not being achieved, the ROC initiates a set of procedures, increasingly restrictive, to force the accession flow towards the identified MOS in the target month.[40]

The ROC is guided by a variety of considerations in its DEP management activities, and the most important ones are as follows:

(1) Seldom Taught (ST), Hard-To-Qualify (HTQ), and extremely-behind-fill MOS are only a small percentage of the FY program for all MOS. Therefore, any overfill resulting from having RECSTA months open beyond the target RECSTA month will not endanger a given RECSTA month's accession mission.

(2) The HSSR (high school senior) market is used to help fill difficult MOS. Open RECSTA months for rising seniors (i.e., having just finished their junior year) are generally limited to OSUT MOS and MOS assigned to Tables 4, 7, and 8 (see below), thereby filling combat arms, hard-to-qualify MOS, and other MOS which the ROC anticipates having difficulty filling.

(3) Summer months are filled quickly with projected senior accessions. However, they are prone to DEP loss because of the long period spent in the DEP. Seniors must be

---

[39] Ideally a RECSTA month will have achieved its accession mission (or be very close to it) at least 3 months in advance. Then the applicants who will accept a short DEP can replace DEP losses. Filling a RECSTA month too full removes career counselor flexibility. Some slack should always be allowed for the exceptions that will occur.

[40] See McWhite and Greenston, 1997, p. 18, for description of these procedures.

evenly spread over the three summer months to preclude excessive DEP losses in any RECSTA month.

(4) Controlling quality during the summer RECSTA months requires special attention. The ROC will initially limit each RECSTA month to about 45 percent fill to ensure that individual MOS (excluding seldom taught and hard-to-qualify MOS) are not prematurely sold out for the year. As a RECSTA month reaches the target percentage of fill, the ROC will change the RUDEP openings to the RECSTA month that has the lowest percentage of fill. When all summer months have been filled to 45 percent, they are selectively opened in order to ensure an even fill into all 3 months. This can happen several times as the summer months are evenly filled.

(5) The ROC must maintain a consistent policy for the guidance counselors. For example, during the summer TSC 3B-4s are generally offered near-term OSUT (one-station unit training) MOS in the current FY. These are less desirable than the longer DEP to the next FY's AIT MOS that are offered to quality applicants. They cannot offer a near-term combat arms seat to one TSC 3B (and imply "take it or leave it") and later offer an attractive AIT MOS to a comparable applicant.

ROC controls are effected through RUDEP tables.[41] One or more MOS are assigned to a RUDEP table which controls the applicant types that can access during the next 25 months. Each MOS must be assigned to a table or it will be open to all categories in all months. The columns of the table represent RECSTA months, from 1 to 25; rows represent applicant type; table entries are X for open or C for closed, indicating whether the MOS is open or closed to applicants of the particular type for the particular month. MOS are assigned to a table based on the kinds of control required. The following MOS tables have been developed for NPS applicants:

Table 1. Seldom taught MOS that have only ten or less class starts during the year. USAREC Recruiting Operations office (RO) cannot afford to miss class seats in these MOS. Missing significant numbers of seats risks missing the annual program. The strategy is to leave all RECSTA months open from the current RECSTA month out to the target RECSTA month(s).

Table 7. Hard-to-qualify MOS, except those that are seldom taught. The strategy is to encourage fill for these MOS by making them available to all open categories and keeping RECSTA months open beyond the target RECSTA month. The hard-to-qualify categorization justifies keeping these MOS at or above the command average fill and therefore overfilling or selling them out.

Tables 2 & 3. MOS that are currently selling at the command average pace or better, and are not classified as seldom taught or hard-to-qualify. Both tables restrict eligibility to TSC 1-3A's, thereby slowing fill. Table 2 will slow fill severely; it is set open only through the month preceding the target RECSTA month. Table 3 will slow fill moderately; it is set open only through the target RECSTA month. Oversold MOS are assigned to either Table 2 or 3 based on the remaining unsold program.

Table 4. MOS that are currently below the command average fill and are not classified as seldom taught / hard-to-qualify. This table has additional RECSTA month(s) open past the target RECSTA month.

---

[41] The ROC operates the RAMS-RUDEP expert system weekly to review MOS assignments among Tables 2, 3, 4, and 8. MOS assignments to other tables are reviewed periodically.

Table 8. MOS that are extremely behind command average fill. This table is available to all open categories and generally open to two months beyond the target RECSTA month.

Tables 18 & 19. For cohort/STP (special training packages). This table is available to all open categories to stimulate fill, and is generally open to the target RECSTA month.

Tables 5 & 6. Special circumstances. These tables are used to close an MOS completely or treat it in some manner that cannot be handled on the other tables.

Procedural changes to support EPAS. A critical RUDEP function is to establish target RECSTA month(s). It is clear that RUDEP could severely constrain EPAS and limit the utility of EOG. For example, too short a DEP robs EPAS of much needed flexibility to recommend optimal person-job matches. We are suggesting a transitional EPAS RUDEP strategy, covering early to late implementation stages.

Consider the early implementation stage. In the first place, MOS assigned to RUDEP Tables 2, 3, 4 and 8 have fill rates slower or faster than the command average. The RUDEP control assures a relatively even fill of MOS, with no MOS falling too far behind or filling up so quickly that later applicants would not see a variety of MOS. Using the RUDEP control does not require an established DEP, so we recommend that the ROC not use these tables. Second, Tables 5 and 6 are used for special circumstances, such as to force fill into specific (missioned) MOS. We recommend evaluation with EPAS simulation mode to assess how well EPAS can support these special requirements.[42] Third, MOS assigned to Tables 1 and 7 are allowed to rapidly fill and would never be held back to channel fill to other MOS. As long as RUDEP permitted sufficient DEP length for these MOS, it would not adversely affect EPAS. Also, a robust DEP is critical to this process and would probably not be in place early in EPAS implementation. Accordingly, we recommend that both these tables continue. Fourth, Tables 18 and 19 cover special training packages whose use vary and are not implemented in EPAS.

In the full implementation stage, a robust DEP will be in place and average estimated performance will be similar to that resulting from a corresponding simulation mode run. We would expect that the RUDEP tables will now "follow" the EOG. The tables must still be used since EPAS will have no control over MOS assignments during REQUEST Look-Up Mode. RUDEP would also be needed to actually stop accessions before or during a (former) RECSTA month.

Coordination Issues Among Army Agencies

Sufficient Screen Exposure of Combat Jobs

USAREC's position is that in order to make their accession mission for combat jobs, it is necessary to have combat MOS training opportunities appear at the "top" of the career counselor screen for virtually all male applicants. Given the salesmanship skills of counselors and the availability of financial incentives, this is a questionable position. Nevertheless, the issue can be addressed in a systematic fashion.

---

[42] Preliminary testing results indicate that EPAS does support these requirements.

Since priority and missioned MOS accession requirements are part of the aggregate allocation problem statement, they will appear in the solution of that problem – that is, in the EOG and merged lists. Preliminary simulation mode testing has not shown a problem, but we are only approximating the live selling situation because we do not represent the general distaste for combat jobs or the financial incentives available to overcome this distaste. The issue must be approached empirically in steps. First, it may be possible to increase the fidelity of the simulation using requirements and seats input data taken directly from the REQUEST system. Second, we are designing the field test to examine this issue; we are planning to modify the set of merge rules as presently proposed in order to gauge their effect on the merged list as presented to the applicants.

Sufficient Training Opportunities on the System

Accession Management Branch – Personnel Command (AMB-PERSCOM) is responsible for training seat management on the REQUEST system. The initial determination of training class schedule and seats is made by Training and Doctrine Command (TRADOC) and is based on projected accession requirements and training capacities. The class schedule and seat data is loaded into the Army Training Requirements & Resources System, and accounted for within that system. This data, in turn, is input into REQUEST via AMB. The seats are managed by AMB, which determines how many seats are seen by REQUEST in the form of "training opportunities". For one thing, AMB inflates the number of training opportunities (over the number of actual seats) to cover anticipated DEP loss. Second, AMB manages training opportunities (TO's) to ensure that MOS training classes are filled in a relatively balanced manner and that missed seats are kept to a minimum. Popular MOS that are selling too fast will be put on the "frozen" list. Thus, AMB determines the number of TO's seen on REQUEST by USAREC/RUDEP, putting a premium on policy coordination between the two. A refrain often heard from USAREC is that there are not enough TO's on the system.[43] Third, AMB, USAREC, and ODCSPER periodically reallocate relatively large blocks of seats through the "trap" process.

Policy coordination is especially important for the proper working of an EPAS-enhanced system. A feasible solution to the aggregate allocation model requires a sufficient number of seats so that FY requirements can be met by applicant supply.[44] Accordingly, the sufficiency of seats for a feasible solution will be tested each week as the model is run with updated input data. In the event that sufficient seats are not on the system, remedial procedures will have to be invoked.

Applicant Supply – Training Requirements Imbalance

Another coordination issue concerns model infeasibility due to an insufficiency of forecasted applicant supply to meet current FY accession and training requirements (given the TO's on the system). This would be a signal that either the forecast is not accurate, or that a genuine shortfall is likely. If the forecast is deemed accurate, ODCSPER/DMPM would provide adjusted requirements for use in the linear programming model, even if they are not immediately promulgated. The EPAS analyst must be ready for this situation, although it may not arise

---

[43] Need to clarify AMB role vis-à-vis that of USAREC/RUDEP controls. Perhaps its key role is in reallocating training seats over the year as requirements change. Does it do other things that RUDEP cannot control?

[44] Assuming for the moment that forecasted supply is sufficient to meet requirements.

frequently because coordination between USAREC and DMPM is already close on matters of supply and demand.

Field Test Issues

The field test is intended to address two objectives. In the first place, the field test is an initial operational test and evaluation, and as such should provide answers to a variety of procedural and efficacy questions. The efficacy issues are those requiring attention beyond that afforded by EPAS prototype simulation (e.g., interplay between EPAS and RUDEP) or those that are not tractable using simulation (e.g., the uncertainty introduced by the difficulty of selling combat jobs). Second, the field test should serve as the vehicle for introducing operational EPAS to REQUEST managers and users in as non-intrusive a manner as possible. Examination of procedural and efficacy questions should give rise to suggestions and modifications for improving the introduction of EPAS. In principle there is considerable flexibility in design and scope of the field test. Initially the scope should probably be limited; once obvious problems are corrected, the scope can be widened. A field test period of 9 to12 months should be adequate.

Procedural questions concern the mechanics of operating the EPAS model and the enhanced REQUEST system. We want to verify that procedures to prepare input data and run the linear programming model work smoothly, and that the EPAS-enhanced system operates transparently to the career counselor (as advertised).

Questions of efficacy arise at two levels. The first concerns how the enhancement changes the applicants' job training choices: (a) How large is the "intersection" of MOS classes from the EOG and REQUEST lists? Recall that this has not been examined in the prototype simulations. (b) Are enough priority MOS appearing toward the top? (c) What alternative merge rules should be tested? USAREC argues that in order to sell 20% of the jobs – i.e., the combat jobs – it must show them to all male applicants. This proposition must be tested since it has implications for the merge rules. It may be necessary to adjust the optimal guidance and make sure that priority MOS appear on top screens with similar frequency as before the EPAS enhancement.

The second question concerns the size of the EPAS-enhanced effect on actual assignments made? What is the average AA composite score under EPAS-enhancement? From which screen and position number did the applicant select his/her job training? Is frequency of request for waiver less under enhanced system? In prototype simulations we could only approximate the real world conditions, and could not take into account applicant distaste for combat jobs and the opposing availability of financial incentives for same. The field test will show more accurately how these forces play out. We note an important caveat on the field test: the effects observed depend on the overall potential for optimization, itself a function of scope and length of the field test, its FY starting point, and size of the DEP bank.

The field test also presents an opportunity to preview the impact of moving to the use of full least-squares (FLS) composites with 9 existing families (today) and subsequently to classification-efficient job families (tomorrow) as discussed in Appendix H (See also Greenston, 2001). Whether or not we avail ourselves of this opportunity will depend upon how much it adds to the field test workload.

References

Alley, W. E. and Teachout, M. S. (1995). *Differential Assignment Potential in the ASVAB: A Simulation of Job Performance Gains* (Interim Technical Paper). Brooks AFB, TX: Human Resources Directorate, Armstrong Laboratory.

Armor, D. J. and Roll, C. R., Jr. (1994). Military Manpower Quality: Past, Present and Future. In B.F. Green & A.S. Mavor (Eds.), *Modeling Cost and Performance for Military Enlistment.* Washington, DC: National Research Council, National Academy Press.

Black, M. (1988). Job Performance and Military Enlistment Standards. In B.F. Green, H. Wing, & A. Wigdor (Eds.), *Linking Military Enlistment Standards to Job Performance.* Washington, DC: National Research Council, National Academy Press.

Brogden, H. (1946). An approach to the problem of differential prediction. *Psychometrika, 11, 39-154.*

Brogden, H. (1959). Efficiency of Classification as a Function of Number of Jobs, Percent Rejected, and the Validity and Intercorrelation of Job Performance Estimates. *Educational and Psychological Measurement, 19, 181-190.*

Green, B.F., Jr., Wing, H., and Wigdor, A. (1988). *Linking Military Enlistment Standards to Job Performance.* Washington, DC: National Research Council, National Academy Press, 1988.

Green, B. F., Jr., and Mavor, A. S. (1994). *Modeling Cost and Performance for Military Enlistment.* Washington, DC: National Research Council, National Academy Press.

Greenston, P., Nelson, A., and Gee, D. (1997). *The Optimal Job-Person Match Case for Attrition Reduction* (Study Report 97-06). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Greenston, P., Walker, S., Mower, D., McWhite, P., Donaldson, L., Lightfoot, M., Diaz, T., Rudnik, R. (1998). *Enlisted Personnel Allocation System (EPAS) Functional Description* (Draft Study Report). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Greenston, P. (2001). *Proposed New Army Aptitude Composites* (Draft Study Report). Alexandria, VA: Army Research Institute for the Behavioral and Social Sciences.

Harrell, T.W. (1992). Short history of the army general classification test. *Journal of Applied Psychology, 77 (6), 875-878.*

Hogan, P.F. and Harris, D.A. (1994). Policy and Management Applications of the Accession Quality Cost / Performance Trade-off Model. In B.F. Green & A.S. Mavor (Eds.), *Modeling Cost and Performance for Military Enlistment.* Washington, DC: National Research Council, National Academy Press.

Horst, P. (1954). A Technique for the Development of a Differential Prediction Battery. *Psychological Monographs, 68 (9, Whole No. 380).*

Johnson, C., Zeidner, J., and Leaman, J. (1992). *Improving Classification Efficiency by Restructuring Army Job Families* (Technical Report 947). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences, Alexandria, VA.

Johnson, C., Zeidner, J., and Vladimirsky, Y. (1996). *Developing Classification-Efficient Job Families Using Differential Assignment Theory Techniques.* Washington, DC: George Washington University, Administrative Sciences Department.

Konieczny, F., Brown, G., Hutton, J. and Stewart, J. (1990). *Enlisted Personnel Allocation System: Final Technical Report.* Vienna, VA: General Research Corporation.

Konieczny, F., Brown, G., Hutton, J. and Stewart, J. (1990). *Enlisted Personnel Allocation System: Final Technical Report Appendices.* Vienna, VA: General Research Corporation.

McWhite, P. and Greenston, P. (1997). *Design Considerations For The Enlisted Personnel Allocation System (EPAS) In Its Interface With The Army Recruit Quota System (REQUEST)* (Study Note 98-03). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Nord, R. D. and Schmitz, E.J. (1989). Estimating Performance and Utility Effects of Alternative Selection and Classification Policies. In J. Zeidner & C.D. Johnson (Eds.), *The Economic Benefits of Predicting Job Performance.* Alexandria, VA: Institute for Defense Analyses.

Rudnik, R. A. and Greenston, P. M. (1996). *Development of an Army Prototype PC-Based Enlisted Personnel Allocation System* (Study Report 96-03). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Smith, D.A. and Hogan, P.F. (1994). The Accession Quality Cost / Performance Trade-off Model." In B.F. Green & A.S. Mavor (Eds.), *Modeling Cost and Performance for Military Enlistment.* Washington, DC: National Research Council, National Academy Press.

Statman, M.A. (1993). *Improving the Effectiveness of Employment Testing Through Classification: Alternative Methods of Developing Test Composites for Optimal Job Assignment and Vocational Counseling* (Ph.D. dissertation). Washington, DC: The George Washington University, Department of Administrative Sciences and Psychology.

Thorndike, R.L. (1950). The problem of classification of personnel. *Psychometrika, 15,* 235.

Weeks, J.L., Mullins, C.J., and Vitola, B.M. (1975). *Airman classification batteries from 1948 to 1975: A review and evaluation* (AFHRL-TR-75-78). Brooks Air Force Base, TX: Air Force Systems Command.

Zeidner, J. and Johnson, C. (1994). Is Personnel Classification A Concept Whose Time Has Passed?" In M. Rumsey, C, Walker, & J. Harris (Eds.), *Personnel Selection and Classification,* Hillsdale, NJ: Lawrence Erlbaum Associates Publishers.

Zeidner, J., Johnson, C., and Vladimirsky, Y. (1998). *Fairness of Proposed New Army ASVAB Test Composites for Restructured Job Families*. Washington, DC: George Washington University, Administrative Sciences Department.

Zeidner, J., Johnson, C., Vladimirsky, Y., and Weldon, S. (2000). *Specifications for an Operational Two-Tiered Classification System for the Army* (Technical Report 1108). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Zeidner, J., Johnson, C.D., and Scholarios, D. (1997). Evaluating Military Selection and Classification Systems in the Multiple Job Context. *Military Psychology*, 9(2), *169-186.*

Zook, Lola M. (1996). *Soldier Selection: Past, Present, and Future* (Special Report 28). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

APPENDIX A
ACRONYMS

AFQT	Armed Forces Qualification Test
AIT	Advanced Individual Training
ARI	Army Research Institute
ATRRS	Army Training Requirements & Resources System
ASVAB	Armed Services Vocational Aptitude Battery
BT	Basic Training
DEP	Delayed Entry Program
DOA	Date Of Availability
EOG	EPAS Optimal Guidance
EPAS	Enlisted Personnel Allocation System
ERI	EPAS-REQUEST Interface
FD	Functional Description
GUI	Graphical User Interface
HIARCY	REQUEST Hierarchical Scoring Program
JPM	Job-Person Match
MB	Megabytes
MEPS	Military Entrance Processing Station
MOS	Military Occupational Specialty
MPI	MOS Priority Index
ODCSPER	Office of the Deputy Chief of Staff for Personnel
PERSCOM	U.S. Army Personnel Command
PERSINSCOM	U.S. Army Personnel Information Systems Command
RECSTA	Receiving Station
REQUEST	Recruit Quota System
RIM	REQUEST Interface Module
RSM	Recruiting Station Month
RSW	Recruiting Station Week
SG	Supply Group
USAREC	United States Army Recruiting Command

APPENDIX B
MOS Cluster Methodology

MOS Class Clusters

MOS class clusters are used to reduce model size. They are easy to create because neither data analysis nor statistical clustering is needed. These clusters are created by grouping Active Army MOS that are open to non-prior service (NPS) applicants by their AA category, qualifying or "cut" score, gender restriction, education requirement, type of training (AIT vs. OSUT), and priority / missioned status. Updates to cluster structure are needed when any of the above MOS characteristics change.

MOS CLUSTERS

```
CLUSTER:  1     AA: CL   PRIMOS: NO          CUT SCORE: 85
             GENDER: M/F    EDUC: HSG/NHS   TRAINING TYPE: AIT
             SEQ  MOS    JOB TITLE
             001  76X    SUBSISTENCE SUPPLIER

CLUSTER:  2     AA: CL   PRIMOS: NO          CUT SCORE: 90
             GENDER: M/F    EDUC: HSG/NHS   TRAINING TYPE: AIT
             SEQ  MOS    JOB TITLE
             002  76P    MATERIAL CONTROL/ACCTING
             003  76V    MAT STORAGE/HANDLING
             004  77F    PETROLEUM SUP SPEC+OF90

CLUSTER:  3     AA: CL   PRIMOS: NO          CUT SCORE: 95
             GENDER: M/F    EDUC: HSG/NHS   TRAINING TYPE: AIT
             SEQ  MOS    JOB TITLE
             005  71G    PATIENT ADMIN SPEC
             006  71L    ADMINISTRATIVE SPEC
             007  71M    CHAPEL ACTIVITIES SPEC
             008  73C    FINANCE SPEC
             009  75B    PERSONNEL ADMIN SPEC
             010  75C    PERSONNEL MGMT SPEC
             011  75D    PERSONNEL RECORDS SPEC
             012  75E    PERSONNEL ACTIONS
             013  75H    PERSONNEL SERVICES SPEC
             014  76J    MED SUPPLY SPEC
             015  76Y    UNIT SUPPLY SPEC
             016  92A    AUTO LOGISTICAL SPEC
             017  92Y    UNIT SUPPLY SPECIALIST

CLUSTER:  4     AA: CL   PRIMOS: NO          CUT SCORE:100
             GENDER: M/F    EDUC: HSG/NHS   TRAINING TYPE: AIT
             SEQ  MOS    JOB TITLE
             018  88N    TRAFFIC MGMT COORD

CLUSTER:  5     AA: CL   PRIMOS: NO          CUT SCORE:105
             GENDER: M/F    EDUC: HSG/NHS   TRAINING TYPE: AIT
             SEQ  MOS    JOB TITLE
             019  73D    ACCOUNTING SPECIALIST

CLUSTER:  6     AA: CL   PRIMOS: NO          CUT SCORE:105
             GENDER: M/F    EDUC:   HSG     TRAINING TYPE: AIT
             SEQ  MOS    JOB TITLE
             020  75F    PERS INFOSYS MGMT SPEC

CLUSTER:  7     AA: CL   PRIMOS: NO          CUT SCORE:110
             GENDER: M/F    EDUC: HSG/NHS   TRAINING TYPE: AIT
             SEQ  MOS    JOB TITLE
             021  46Q    JOURNALIST
             022  46R    BROADCAST JOURNALIST

CLUSTER:  8     AA: CL   PRIMOS: NO          CUT SCORE:110
             GENDER: M/F    EDUC:   HSG     TRAINING TYPE: AIT
             SEQ  MOS    JOB TITLE
             023  71D    LEGAL CLERK

CLUSTER:  9     AA: EL   PRIMOS: NO          CUT SCORE: 85
```

```
          GENDER:  M     EDUC: HSG/NHS   TRAINING TYPE: AIT
          SEQ  MOS     JOB TITLE
          024  96R     GROUND SURVEILLANCE RADA

CLUSTER: 10      AA: EL    PRIMOS: NO          CUT SCORE: 90
          GENDER: M/F    EDUC: HSG/NHS   TRAINING TYPE: AIT
          SEQ  MOS     JOB TITLE
          025  31L     WIRE SYSTEMS INSTALLER

CLUSTER: 11      AA: EL    PRIMOS: NO          CUT SCORE: 95
          GENDER: M/F    EDUC: HSG/NHS   TRAINING TYPE: AIT
          SEQ  MOS     JOB TITLE
          026  14L     AN/TSQ-73 AIR DEF COM&CTRL
          027  27B     LAND COMBAT SUPPORT SYST
          028  27E     TOW/DRAGON REPAIRER
          029  27G     CHAPARRAL/REDEYE REPAIRER
          030  27H     HAWK FIRING SECTION REPAIR
          031  27M     MLRS REPAIRER
          032  31M     MULTICHANNEL COMMUNICA OP
          033  31N     TACTICAL CIRCUIT CONTROLLR
          034  31Q     TACTICAL SAT/MICRO SYS OPER
          035  31U     SIG SUPT SYS SPEC+SC95
          036  31V     TACTICAL COMMUNICATIONS
          037  35K     AVIONIC MECHANIC
          038  39E     SPEC ELECTRONIC DEVICE REP
          039  45G     CONTROL SYSTEMS REP
          040  52G     TRANSMISSION AND DIST SPEC
          041  68N     AVIONIC MECHANIC
          042  93F     FLD ARTILLERY METEO CREW

CLUSTER: 12      AA: EL    PRIMOS: NO          CUT SCORE: 95
          GENDER:  M     EDUC: HSG/NHS   TRAINING TYPE: AIT
          SEQ  MOS     JOB TITLE
          043  51R     INTERIOR ELECTRICIAN

CLUSTER: 13      AA: EL    PRIMOS: NO          CUT SCORE:100
          GENDER: M/F    EDUC: HSG/NHS   TRAINING TYPE: AIT
          SEQ  MOS     JOB TITLE
          044  27F     VULCAN REPAIRER
          045  27T     AVENGER SYSTEM REPAIR
          046  29M     TACT SATEL/MICROWAVE REP
          047  29N     TELEPHONE CENTRAL OFF REP
          048  31R     MULTICHAN TRANS SYS/OPER
          049  35L     AVIONIC COMM EQUIPMENT REP
          050  35N     WIRE SYSTEMS EQUIP REPAIRER
          051  35Q     AVIONIC FLIGHT SYSTEMS REP
          052  35R     AVIONIC SPECIAL EQUIPMENT RE
          053  36M     WIRE SYSTEMS OPERATOR
          054  55G     NUCLEAR WEAP MAINT SPEC
          055  68L     AVIONIC COMM EQ REPAIR
          056  68Q     AVIONIC FLIGHT SYS REPAIR
          057  68R     AVIONIC RADAR REPAIR
          058  68X     AH-64 ARMT/ELEC SYS RE
          059  68Z     AVIONIC COMM EQ REPAIR

CLUSTER: 14      AA: EL    PRIMOS: NO          CUT SCORE:105
          GENDER: M/F    EDUC: HSG/NHS   TRAINING TYPE: AIT
          SEQ  MOS     JOB TITLE
```

```
                060  29S    COMSEC EQUIPMENT REPAIR
                061  31F    MSE NETWORK SWITCH OPR
                062  35D    AIR TRAFFIC CTRL EQUIP REP
                063  35F    ????
                064  93D    AIR TRAFFIC SYSTEMS REP

CLUSTER: 15       AA: EL   PRIMOS: NO          CUT SCORE:110
                GENDER: M/F    EDUC: HSG/NHS   TRAINING TYPE: AIT
                SEQ  MOS    JOB TITLE
                065  24C    IMPROVED HAWK FIRING SEC MEC
                066  24G    IMPROVED HAWK INFORMATIO MEC
                067  24K    IMPROVED HAWK CONT WAVE REP
                068  25R    VISUAL INFO/AUDIO EQ REP
                069  27J    HAWK EQ/PULSE RADAR REP
                070  27K    HAWK FIRE CTL/CNTS RADAR REP
                071  27N    FORWARD AREA ALERTING RAD RE
                072  27X    PATRIOT SYSTEM REPAIRER
                073  29E    COMMUNICAT-ELECT RADIO REP
                074  29J    TELETYPEWRITER EQ REP
                075  29V    START MICROWAVE SYS REP
                076  35B    LAND COMBAT SUP SYS TEST SP
                077  35E    RADIO AND COMM SEC REPAIRER
                078  35G    MEDICAL EQUIPMENT REPAIRER
                079  35Y    INTEGR FAM TEST EQ OP/MAINT
                080  39B    AUTOMATIC TEST EQUIP OP
                081  39Y    FLD ARTLRY FIRE DIR SYS REP
                082  74G    TELECOM COMPUTER OPER/MAING

CLUSTER: 16       AA: EL   PRIMOS: NO          CUT SCORE:110
                GENDER: M/F    EDUC:   HSG     TRAINING TYPE: AIT
                SEQ  MOS    JOB TITLE
                083  31P    MICROWAVE SYSTEMS OP/MAINT
                084  35J    TELECOMM TERM DEVICE REPR
                085  35M    ????
                086  39G    AUTO COMMO CMPTR SYS REP

CLUSTER: 17       AA: EL   PRIMOS: NO          CUT SCORE:110
                GENDER:  M     EDUC: HSG/NHS   TRAINING TYPE: AIT
                SEQ  MOS    JOB TITLE
                087  24M    VULCAN SYSTEM MECHANIC
                088  24N    CHAPARRAL SYSTEM MECHANIC

CLUSTER: 18       AA: EL   PRIMOS: NO          CUT SCORE:115
                GENDER: M/F    EDUC: HSG/NHS   TRAINING TYPE: AIT
                SEQ  MOS    JOB TITLE
                089  35C    ????
                090  39C    TARGET ACQ/SURV RADAR REP

CLUSTER: 19       AA: EL   PRIMOS: NO          CUT SCORE:120
                GENDER: M/F    EDUC: HSG/NHS   TRAINING TYPE: AIT
                SEQ  MOS    JOB TITLE
                091  29Y    SAT COM SYS REPAIR
                092  35H    CALIBRATION SPECIALIST

CLUSTER: 20       AA: EL   PRIMOS: NO          CUT SCORE:120
                GENDER: M/F    EDUC:   HSG     TRAINING TYPE: AIT
                SEQ  MOS    JOB TITLE
                093  31S    SATELLITE COMM SYS/OPER
```

CLUSTER: 21 AA: FA PRIMOS: NO CUT SCORE:100
GENDER: M EDUC: HSG/NHS TRAINING TYPE: AIT

SEQ	MOS	JOB TITLE
094	13F	FIRE SUPPORT SPECIALIST
095	13P	MLRS/LANCE FIRE DIR SPEC

CLUSTER: 22 AA: GM PRIMOS: NO CUT SCORE: 85
GENDER: M/F EDUC: HSG/NHS TRAINING TYPE: AIT

SEQ	MOS	JOB TITLE
096	43M	FABRIC REPAIR SPEC
097	57E	LAUNDRY/BATH SPEC

CLUSTER: 23 AA: GM PRIMOS: NO CUT SCORE: 90
GENDER: M/F EDUC: HSG/NHS TRAINING TYPE: AIT

SEQ	MOS	JOB TITLE
098	43E	PARACHUTE RIGGER
099	44B	METAL WORKER
100	45B	SMALL ARMS REPAIRER
101	51B	CARPENTER/MASON
102	51M	FIREFIGHTER
103	57F	GRAVE REGISTRATION SPEC
104	62E	HEAVY EQ OPERATOR
105	62F	LIFT/LOAD EQ OPERATOR
106	62H	CONCRETE EQ OPERATOR
107	62J	GENERAL CONSTRUCTION
108	77W	WATER TREATMT SPECIALIST
109	88H	CARGO SPECIALIST
110	92M	MORTUARY AFFAIRS SPECIALIST
111	92R	PARACHUTE RIGGER

CLUSTER: 24 AA: GM PRIMOS: NO CUT SCORE: 90
GENDER: M EDUC: HSG/NHS TRAINING TYPE: AIT

SEQ	MOS	JOB TITLE
112	51K	PLUMBER

CLUSTER: 25 AA: GM PRIMOS: NO CUT SCORE: 95
GENDER: M/F EDUC: HSG/NHS TRAINING TYPE: AIT

SEQ	MOS	JOB TITLE
113	41C	FIRE CONTROL INS REP
114	55B	AMMO SPECIALIST
115	62G	QUARRYING SPECIALIST

CLUSTER: 26 AA: GM PRIMOS: YES CUT SCORE: 95
GENDER: M EDUC: HSG/NHS TRAINING TYPE: AIT

SEQ	MOS	JOB TITLE
116	45T	M2/BRADLEY FV MECH

CLUSTER: 27 AA: GM PRIMOS: NO CUT SCORE:100
GENDER: M/F EDUC: HSG/NHS TRAINING TYPE: AIT

SEQ	MOS	JOB TITLE
117	42C	ORTHOTIC SPECIALIST
118	42D	DENTAL LAB SPEC
119	42E	OPTICAL LAB SPEC
120	44E	MACHINIST
121	45K	TANK TURRET REPAIRER
122	45L	ARTILLERY REPAIRER
123	52C	UTILITIES EQ REP

```
                124  52D    GENERATOR EQ REOR
                125  52F    TURBINE ENG GEN REP

CLUSTER: 28        AA: GM   PRIMOS: NO           CUT SCORE:100
                GENDER:  M     EDUC: HSG/NHS   TRAINING TYPE: AIT
                SEQ  MOS    JOB TITLE
                126  45D    FIELDART TURRET MECH

CLUSTER: 29        AA: GM   PRIMOS: NO           CUT SCORE:105
                GENDER: M/F    EDUC: HSG/NHS   TRAINING TYPE: AIT
                SEQ  MOS    JOB TITLE
                127  55D    EXPL ORD DISPOSAL

CLUSTER: 30        AA: MM   PRIMOS: NO           CUT SCORE: 90
                GENDER: M/F    EDUC: HSG/NHS   TRAINING TYPE: AIT
                SEQ  MOS    JOB TITLE
                128  62B    CONSTRUCTION EQ REP
                129  63B    LIGHT WHEELED VEHICLE OPR
                130  63H    TRACK VEHICLE REPAIR
                131  63J    QUARTERMASTER REPR
                132  63W    WHEEL VEH REPAIR
                133  88T    RAILWAY SECTION REPR (RC)

CLUSTER: 31        AA: MM   PRIMOS: NO           CUT SCORE: 95
                GENDER: M/F    EDUC: HSG/NHS   TRAINING TYPE: AIT
                SEQ  MOS    JOB TITLE
                134  88U    RAILWAY OPERATORS CREW

CLUSTER: 32        AA: MM   PRIMOS: NO           CUT SCORE:100
                GENDER: M/F    EDUC: HSG/NHS   TRAINING TYPE: AIT
                SEQ  MOS    JOB TITLE
                135  68J    AIRCRAFT FIRE CONTROL
                136  88K    WATERCRAFT OPERATOR
                137  88P    RAILWAY EQUIPMENT REPR (RC)

CLUSTER: 33        AA: MM   PRIMOS: NO           CUT SCORE:100
                GENDER:  M     EDUC: HSG/NHS   TRAINING TYPE: AIT
                SEQ  MOS    JOB TITLE
                138  45N    M60A1 TANK TUR MECH
                139  63N    M6 TANK SYS MECH

CLUSTER: 34        AA: MM   PRIMOS: YES          CUT SCORE:100
                GENDER:  M     EDUC: HSG/NHS   TRAINING TYPE: AIT
                SEQ  MOS    JOB TITLE
                140  45E    TANK TURRET MECHANIC
                141  63E    ABRAMS TANK MECH

CLUSTER: 35        AA: MM   PRIMOS: NO           CUT SCORE:105
                GENDER: M/F    EDUC: HSG/NHS   TRAINING TYPE: AIT
                SEQ  MOS    JOB TITLE
                142  14E    PATRIOT FILE CONT ENG OPER
                143  24T    PATRIOT SYSTEM MECHANIC
                144  63G    FUEL SYSTEMS REPAIR
                145  63S    HEAVY WHEEL MECHANIC
                146  63Y    TRACK VEH MECHANIC
                147  67G    UTILITY AIRPLANE REPAIRER
                148  67H    OBSERV PLANE REPAIR
                149  67N    UTIL CHOPPER REPAIR
```

150	67R	AH-64 ATTACK HELICOPTER
151	67S	SCOUT HELICOPTER REP
152	67T	TRANSPORT CHOPPER REPAIR
153	67U	MEDIUM CHOPPER REPAIR
154	67V	OBSV/SCOUT HELO REP
155	67Y	ATTACK COPTER REP
156	68B	AIRCRAFT P-PLANT REP
157	68D	AIRCRAFT P-TRAIN REP
158	68F	AIRCRAFT ELECTRICIAN
159	68G	AIRCRAFT STRUCT REP
160	68H	PNEUDRAULICS REPAIR
161	88L	WATERCRAFT ENGINEER

CLUSTER: 36 AA: MM PRIMOS: NO CUT SCORE:105
GENDER: M EDUC: HSG/NHS TRAINING TYPE: AIT

SEQ	MOS	JOB TITLE
162	63D	FIELD ART SYS MECH

CLUSTER: 37 AA: MM PRIMOS: YES CUT SCORE:105
GENDER: M EDUC: HSG/NHS TRAINING TYPE: AIT

SEQ	MOS	JOB TITLE
163	63T	ITV/IFV/CFV MECH

CLUSTER: 38 AA: OF PRIMOS: NO CUT SCORE: 90
GENDER: M/F EDUC: HSG/NHS TRAINING TYPE: AIT

SEQ	MOS	JOB TITLE
164	14M	MAN PORTABLE AIR DEF SYS CR
165	88M	MOTOR TRANSPORT OPERATOR
166	92G	FOOD SERVICE SPECIALIST
167	94B	FOOD SERVICE SPEC

CLUSTER: 39 AA: OF PRIMOS: NO CUT SCORE: 90
GENDER: M EDUC: HSG/NHS TRAINING TYPE: AIT

SEQ	MOS	JOB TITLE
168	14S	AVENGER CREWMEMBER
169	16S	MANPADS CREWMAN

CLUSTER: 40 AA: OF PRIMOS: NO CUT SCORE:100
GENDER: M/F EDUC: HSG/NHS TRAINING TYPE: AIT

SEQ	MOS	JOB TITLE
170	14D	HAWK MISSILE CREW
171	14T	PATRIOT LAUNCH STA ENH OPER
172	15E	PERSHING MISSILE CREW
173	16D	HAWK MISSILE CREW
174	16E	HAWK FILE CONTROL CREW
175	16T	PATRIOT MISSILE CREW
176	25L	AN/TSG 73 AIR DEF ART OP/REP
177	91M	HOSP FOOD SVC SPECIALIST

CLUSTER: 41 AA: OF PRIMOS: NO CUT SCORE:100
GENDER: M EDUC: HSG/NHS TRAINING TYPE: AIT

SEQ	MOS	JOB TITLE
178	14J	EW SYS OPER ALERTING RADAR
179	14R	SIGHT FORWARD HVY CREW
180	16J	DEFENSE ACQUISITION RADA
181	16P	ADA SHORT RANGE MISSILE
182	16R	ADA SHORT RANGE GUNNERY
183	16X	AIR CREWMEMBER

```
CLUSTER: 42      AA: OF    PRIMOS: NO            CUT SCORE:105
            GENDER:  M      EDUC: HSG/NHS   TRAINING TYPE: AIT
            SEQ  MOS     JOB TITLE
            184  13M     MULTIPLE LAUNCH ROCKET S

CLUSTER: 43      AA: SC    PRIMOS: NO            CUT SCORE: 90
            GENDER: M/F     EDUC: HSG/NHS   TRAINING TYPE: AIT
            SEQ  MOS     JOB TITLE
            185  31K     COMBAT SIGNALER
            186  72E     TELECOM CTR OPER
            187  74C     REC TELCOM CTR REP+EL90

CLUSTER: 44      AA: SC    PRIMOS: NO            CUT SCORE: 95
            GENDER: M/F     EDUC: HSG/NHS   TRAINING TYPE: AIT
            SEQ  MOS     JOB TITLE
            188  96H     AERIAL SENSOR SPEC

CLUSTER: 45      AA: SC    PRIMOS: NO            CUT SCORE:100
            GENDER: M/F     EDUC: HSG/NHS   TRAINING TYPE: AIT
            SEQ  MOS     JOB TITLE
            189  13T     REMOTELY PILOTED VEH CREW
            190  31C     SINGLE CHANNEL RADIO OPE
            191  31D     MSE TRSMSN SYS OPER+EL100

CLUSTER: 46      AA: SC    PRIMOS: NO            CUT SCORE:100
            GENDER:  M      EDUC: HSG/NHS   TRAINING TYPE: AIT
            SEQ  MOS     JOB TITLE
            192  13R     FIELD ARTILLERY FIREFIND OP

CLUSTER: 47      AA: SC    PRIMOS: NO            CUT SCORE:105
            GENDER: M/F     EDUC:   HSG     TRAINING TYPE: AIT
            SEQ  MOS     JOB TITLE
            193  96U     UNMANNED AERIAL VEH OPER

CLUSTER: 48      AA: ST    PRIMOS: NO            CUT SCORE: 85
            GENDER: M/F     EDUC: HSG/NHS   TRAINING TYPE: AIT
            SEQ  MOS     JOB TITLE
            194  25P     VISUAL/AUDIO DOC SYS SP
            195  81C     CARTOGRAPHER
            196  81L     PRINTING AND BINDERY SPEC
            197  83E     PHOTO LAYOUT SPEC
            198  83F     PHOTOLITHOGRAPHER

CLUSTER: 49      AA: ST    PRIMOS: NO            CUT SCORE: 95
            GENDER: M/F     EDUC: HSG/NHS   TRAINING TYPE: AIT
            SEQ  MOS     JOB TITLE
            199  25Q     GRAPHICS DOC SPECIALIST
            200  25S     STILL DOCUMENTATION SPE
            201  51T     TECHNICAL ENGINEERING SPEC
            202  77L     PETROLEUM LAB SPEC
            203  81B     TECH DRAFTING SPEC
            204  82B     CONSTRUCTION SURVEYOR
            205  82D     TOPOGRAPHIC SURVEYOR
            206  91A     MEDICAL SPECIALIST
            207  91B     MEDICAL SPECIALIST
            208  91D     OPERATING ROOM SPEC
            209  91E     DENTAL SPECIALIST
```

210	91F	PSYCHIATRIC SPECIALIST
211	91H	ORTHOPEDIC SPECIALIST
212	91J	PHYSICAL THERAPY SPEC
213	91L	OCCUPATIONAL THERAPY SPE
214	91N	CARDIAC SPECIALIST
215	91Q	PHARMACY SPECIALIST
216	91S	ENVIR HEALTH SPEC
217	91T	ANIMAL CARE SPEC
218	91U	ENT SPECIALIST
219	91Y	EYE SPECIALIST
220	92B	MEDICAL LAB SPEC
221	93P	FLIGHT OPER COORD
222	96D	IMAGE INTERCEPTER
223	97G	SIGNAL SECURITY SPEC
224	97X	LINGUIST
225	98D	EMITTER LOC/IDENTIFIER
226	98G	EW/SIGINT VOICE INTERCEP
227	98H	MORSE INTERCEPTOR
228	98K	NONMORSE INTERCEPT OPER
229	98X	EW/SIGINT SPEC (LING)

CLUSTER: 50 AA: ST PRIMOS: NO CUT SCORE: 95
GENDER: M/F EDUC: HSG TRAINING TYPE: AIT

SEQ	MOS	JOB TITLE
230	25M	GRAPHICS DOCUMENTATION SPEC
231	25V	COMBAT DOC/PROD SPECIALIST
232	97E	INTERROGATOR
233	97L	TRANSLATOR/INTERPRETER (RC)

CLUSTER: 51 AA: ST PRIMOS: NO CUT SCORE: 95
GENDER: M EDUC: HSG/NHS TRAINING TYPE: AIT

SEQ	MOS	JOB TITLE
234	13C	TACFIRE OPERATIONS SPECI
235	13E	CANNON FIRE DIRECTION SP
236	82C	FLD ARTILLERY SURVEYOR

CLUSTER: 52 AA: ST PRIMOS: NO CUT SCORE:100
GENDER: M/F EDUC: HSG/NHS TRAINING TYPE: AIT

SEQ	MOS	JOB TITLE
237	74B	INFORMATION SYSTEMS OPER
238	74D	COMPUTER/MACHINE OPR
239	74F	PROGRAMMER/ANALYST
240	81T	TOPOGRAPHIC ANALYST
241	91P	X-RAY SPECIALIST
242	91R	VETERINARY FOOD INSP
243	93C	AIR TRAFFIC CONTROL OPER

CLUSTER: 53 AA: ST PRIMOS: NO CUT SCORE:100
GENDER: M/F EDUC: HSG TRAINING TYPE: AIT

SEQ	MOS	JOB TITLE
244	38A	CIVIL AFFAIRS SPECIALIST
245	55R	AMMO STOCK CONTROL & ACC SP
246	81Q	TERRAIN ANALYST

CLUSTER: 54 AA: ST PRIMOS: NO CUT SCORE:100
GENDER: M EDUC: HSG/NHS TRAINING TYPE: AIT

SEQ	MOS	JOB TITLE

```
           247  18D    SPECIAL FORCES MED SERGEANT?

CLUSTER: 55      AA: ST   PRIMOS: NO           CUT SCORE:105
           GENDER: M/F    EDUC: HSG/NHS   TRAINING TYPE: AIT
           SEQ  MOS    JOB TITLE
           248  37F    PSYCHOLOGICAL OPS SPEC
           249  71C    EXEC ADMIN ASST
           250  91X    MENTAL HEALTH SPECIALIST
           251  93B    AEROSCOUT OBSERVER
           252  96F    PSYCHOLOGICAL OPS SPEC
           253  98C    EW/SIGINT ANALYST

CLUSTER: 56      AA: ST   PRIMOS: NO           CUT SCORE:105
           GENDER: M/F    EDUC:   HSG     TRAINING TYPE: AIT
           SEQ  MOS    JOB TITLE
           254  91G    BEHAVIORAL SCIENCE SPEC
           255  96B    INTELLIGENCE ANALYST
           256  98J    NONCOMM INTERCEPTER

CLUSTER: 57      AA: ST   PRIMOS: NO           CUT SCORE:105
           GENDER:  M     EDUC: HSG/NHS   TRAINING TYPE: AIT
           SEQ  MOS    JOB TITLE
           257  97B    COUNTERINTELL ASST

CLUSTER: 58      AA: ST   PRIMOS: NO           CUT SCORE:110
           GENDER: M/F    EDUC: HSG/NHS   TRAINING TYPE: AIT
           SEQ  MOS    JOB TITLE
           258  91K    MEDICAL LABORATORY SPEC

CLUSTER: 59      AA: ST   PRIMOS: NO           CUT SCORE:110
           GENDER:  M     EDUC: HSG/NHS   TRAINING TYPE: AIT
           SEQ  MOS    JOB TITLE
           259  33V    EW/INTCPT AER SYS REP

CLUSTER: 60      AA: ST   PRIMOS: NO           CUT SCORE:115
           GENDER: M/F    EDUC: HSG/NHS   TRAINING TYPE: AIT
           SEQ  MOS    JOB TITLE
           260  33R    EW/I INTERCEPT AVN SYS RP
           261  33T    EW/I TAC SYS REP
           262  33Y    STRATEGIC SYSTEM REPAIT

CLUSTER: 61      AA: CO   PRIMOS: NO           CUT SCORE: 90
           GENDER:  M     EDUC: HSG/NHS   TRAINING TYPE: OSUT
           SEQ  MOS    JOB TITLE
           263  11B    INFANTRY (ACTIVE ARMY)
           264  11C    INFANTRY (ACTIVE ARMY)
           265  11H    INFANTRY (ACTIVE ARMY)
           266  11M    INFANTRY (ACTIVE ARMY)
           267  12B    COMBAT ENGINEER AIRBORNE
           268  12C    BRIDGE CREWMAN
           269  12F    ENGINEER TRACKED VEHICLE
           270  19D    CAVALRY SCOUT
           271  19E    M48-M60 ARMOR CREWMAN

CLUSTER: 62      AA: CO   PRIMOS: YES          CUT SCORE: 90
           GENDER:  M     EDUC: HSG/NHS   TRAINING TYPE: OSUT
           SEQ  MOS    JOB TITLE
           272  11X    INFANTRY (ACTIVE ARMY)
```

```
               273  19K    ARMOR SPECIALIST

CLUSTER: 63        AA: FA   PRIMOS: YES          CUT SCORE: 85
               GENDER:  M     EDUC: HSG/NHS   TRAINING TYPE: OSUT
               SEQ  MOS    JOB TITLE
               274  13B    CANNON CREWMAN

CLUSTER: 64        AA: ST   PRIMOS: NO           CUT SCORE: 95
               GENDER: M/F    EDUC: HSG/NHS   TRAINING TYPE: OSUT
               SEQ  MOS    JOB TITLE
               275  54B    CHEMICAL OPER SPECIALIST

CLUSTER: 65        AA: ST   PRIMOS: NO           CUT SCORE:100
               GENDER: M/F    EDUC: HSG/NHS   TRAINING TYPE: OSUT
               SEQ  MOS    JOB TITLE
               276  95B    MILITARY POLICE
               277  95C    CORRECTIONS SPECIALIST
```

APPENDIX C
Supply Group Computation Methodology

1. INTRODUCTION

We describe in this appendix the methodology employed in developing classification-efficient Army recruit subgroups for the Enlisted Personnel Allocation System (EPAS). In this classification problem, the goal is to form allocation supply groups, each composed of recruits with as similar as possible predicted job performance profiles, using a strategy that is consistent with subsequent EPAS procedures. The number of supply groups was treated as an empirical problem but subject to EPAS constraints and current Army policy requirements.

Section 2 presents the method for developing the supply groups. The method considered the intended EPAS implementation of supply groups. This provided the overall framework for the design of the supply group formation strategy. In Section 3 we present a description of the supply groups that were formed based on our analysis. In Section 4 we provide a monitoring method that may be used to detect changes in the overall characteristics in Armed Services Vocational Aptitude Battery (ASVAB) scores of Army recruits that can potentially affect the efficiency of the supply groups.

Supply groups are characterized by mission group categories, ASVAB test scores, and expected job performance profiles. Mission groups are formed based on a three-way classification using gender, education, and the AFQT level of recruits. ASVAB and aptitude area (AA) profiles of a supply group are based on the means of ASVAB and AA scores of all potential recruits belonging to the group. In the implementation of EPAS, connections are allowed between a supply group and jobs whose cut scores are equal to or exceeded by the corresponding supply group mean AA score.

2. METHOD

2.1 WORKING SAMPLE

The Army Research Institute (ARI) provided a database of recruits who contracted during the 1994, 1995 and 1996 fiscal years. We excluded from our analysis individuals with civilian-trained occupations and those with prior service. Also dropped were recruits whose education status could not be determined from the database. A working sample was developed by combining all 1996 recruits with 50% of 1995 and 25% of 1994 AFQT Category I-IIIB recruits, and 100% of 1995 and 1994 Category IV recruits. This composite database was employed to gain as much stability as possible in the computation of the supply group means while at the same time giving more weight to the more recent recruit population. Category IV contractees account for a very small proportion of Army recruits, and as such, a 100% sample was taken from each year in order to obtain stable supply group means in this mission group. Table 1 shows the distribution of the working sample by mission category. The ARI database included ASVAB scores and AA predicted job performance scores of individual recruits—the main analysis variables used in our work.

Table 1. Distribution of Working Sample by Mission Categories

Sex	AFQT	Education	N	Percent
Male	**1-3A**	**H.S. Grad.**	**43,674**	**31.01**
	1-3A	**H.S. Senior**	**21,307**	**15.13**
	1-3A	**Non-Grad.**	**7,637**	**5.42**
	3B	**H.S. Grad.**	**21,964**	**15.59**
	3B	**H.S. Senior**	**10,296**	**7.31**
	3B	**Non-Grad.**	**774**	**0.55**
	4	**H.S. Grad.**	**3,765**	**2.67**
	4	**H.S. Senior**	**35**	**0.02**
	4	**Non-Grad.**	**73**	**0.05**
Female	**1-3A**	**H.S. Grad.**	**14,299**	**10.15**
	1-3A	**H.S. Senior**	**5,662**	**4.02**
	1-3A	**Non-Grad.**	**1,020**	**0.72**
	3B	**H.S. Grad.**	**7,272**	**5.16**
	3B	**H.S. Senior**	**2,728**	**1.94**
	3B	**Non-Grad.**	**109**	**0.08**
	4	**H.S. Grad.**	**219**	**0.16**
	4	**H.S. Senior**	**5**	**0.00**
	4	**Non-Grad.**	**2**	**0.00**
TOTAL			140,841	100.00

Principal Component Analysis. The four main principal components associated with ASVAB scores were used extensively in the preliminary analysis, clustering strategy, and presentation and description of final supply groups. A principal component analysis with varimax rotation was conducted on the nine ASVAB scores of all recruits in our working sample. The loadings of the four final rotated components, which correspond to the traditional ASVAB factors, are given in Table 2. These four components accounted for a combined 79 percent of the variability of the test scores. Principal component scores were computed for each recruit in the working sample.

Table 2. Rotated Factor Loadings of Four Main Components

ASVAB	Principal Components			
Test	QUANT	VEBAL	TECH	SPEED
GS	0.5879	0.5090	0.2644	-0.1301
AR	**0.7920**	0.0908	0.2638	0.1751
NO	0.3388	-0.2468	-0.0081	**0.8022**
CS	-0.0717	0.4134	-0.1219	**0.8169**
AS	0.0671	0.0779	**0.9180**	-0.0840
MK	**0.8907**	0.0069	0.0100	0.1122
MC	0.4111	0.2335	**0.7088**	-0.0360
EI	0.0136	0.7107	**0.5032**	0.0306
VE	0.1268	**0.9124**	0.0409	0.0823

2.2 CLUSTERING STRATEGY

ASVAB test scores of Army recruits exhibited no natural cluster structure, but instead tended to follow a multivariate normal distribution that is truncated on the tails. A similar no natural structure observation was made within each mission group, but with skewness and kurtosis that suggested substantial deviation from multivariate normal. Cluster analysis was employed primarily as a data reduction technique to form homogeneous supply groups or clusters by mission category.

A two-stage clustering strategy was used to form supply groups. The two stages of our cluster analysis are described in detail below. In the first stage, macro clusters were obtained for the entire working sample of 140,841 recruits. The results in this initial stage were used to determine empirically the desired number of clusters in the mission group-level cluster analysis that was carried out in the second stage. In general, a large and variable mission group will tend to spread across a larger number of macro clusters and would require more supply groups or clusters to achieve a desirable level of differentiation. On the other hand, a small and less variable mission group will typically be distributed densely in fewer macro clusters and require a fewer number of supply groups. The empirical allocation strategy employed at the end of the first stage used this rationale to determine the total number of clusters that would reflect both the empirical properties of the recruit distribution and the relative sizes and importance of the mission groups.

2.2.1 MACRO CLUSTER ANALYSIS

The macro cluster analysis empirically segmented the recruit population into a small set of homogeneous macro clusters. Our purpose was to use the macro clusters in conjunction with the mission groups to estimate the final number and composition of the supply groups. Initially, we employed the Ward's hierarchical agglomerative procedure, using a sub-sample of 10,000 recruits and the four principal components (shown in Table 2) as classification variables to assign individuals to clusters. Next, an iterated nearest-centroid procedure with ASVAB test scores as classification variables was used to refine the clusters. In this procedure cluster centroids were recomputed after all individuals were identified with a cluster. Each individual then was reassigned based on the reconfigured cluster centroids. The process of repeated assignment of individuals and computation of centroids was terminated when 20 relatively stable cluster centroids were attained.

Finally, approximately 110 supply groups were derived from the mission groups and 20 macro clusters by carrying out a macro cluster by mission category cross-tabulation of recruits. For each mission group, the number of macro clusters in which they appeared in large proportions was counted. The general idea was to determine the number of clusters where a mission group had substantial membership, i.e., where clusters were relatively dense. This analysis was combined with prior knowledge of the relative importance of the mission group to come up with the final allocation of supply groups to each mission group. Our goal was to obtain supply groups that reflected the relative sizes and importance of the mission groups and were homogeneous in ASVAB and AA scores.

2.2.2 MISSION LEVEL CLUSTER ANALYSIS

Final supply groups were formed by carrying out the iterated nearest centroid procedure within each mission group. In each mission level cluster analysis, the number of clusters was set to the number of supply groups allocated to the relevant mission group at the end of the macro cluster analysis. The means of the mission group's ASVAB scores within each of these macro clusters were used as initial seeds in the mission level cluster analysis. A process of repeatedly reassigning individuals to clusters and recomputing centroids was conducted until stable clusters were obtained.

At the completion of the mission level analysis, centroids were computed using the AA score coordinates. Standard deviations were calculated for both ASVAB and AA scores for each final supply group. Additionally, major percentiles of AA scores were obtained, as these are potentially useful in the construction of cut scores.

After we examined the full supply group clusters developed in the mission level analyses, the number of clusters was increased for the male, high school graduate, Category I-IIIA mission group to achieve relatively more differentiation befitting its size (31% of the population) and importance in the Army. A macro level cluster analysis was carried out to form 30 clusters as described in Section 2.2.1. Category I-IIIA recruits were substantially distributed in 26 of these macro clusters; thus, supply group allocation for this mission category was increased to 26. The mission level cluster analysis was repeated using this new allocation to form the final Category I-IIIA supply group centroids. The other mission groups were not reconfigured.

3. RESULTS

A total of 130 supply groups were distributed across 14 working mission categories. The final allocation is summarized in Table 3, where mission categories are grouped by their relative importance in current Army recruitment policy.

Table 3. Supply Group Allocation by Mission Categories

Priority	Sex	AFQT	Education	No. Groups	Percent
1	Male	1-3A	H.S. Grad.	26	20.00
	Male	1-3A	H.S. Senior	16	12.31
	Male	3B	H.S. Grad.	14	10.77
	Male	3B	H.S. Senior	9	6.92
2	Male	1-3A	Non-Grad.	8	6.15
	Male	3B	Non-Grad.	4	3.08
	Female	1-3A	H.S. Grad.	12	9.23
	Female	1-3A	H.S. Senior	8	6.15
	Female	1-3A	Non-Grad.	5	3.85
	Female	3B	H.S. Grad.	8	6.15
	Female	3B	H.S. Senior	7	5.38
	Female	3B	Non-Grad.	3	2.31
3	Male	4	All	7	5.38
	Female	4	All	3	2.31
	TOTAL			130	100.00

The allocation shown above reflects the level of priority (1=Highest), the size, and the ASVAB score variability of a mission group. A similarity in the ASVAB profiles of mission groups with the same AFQT category was observed. This is not surprising since AFQT is based on ASVAB quantitative and verbal tests, which represent the first two principal components of ASVAB. Within a priority level, the difference in the allocated number of supply groups is mainly attributable to the group's relative size. For example, female Category 1-IIIA graduates comprise the fourth largest mission group and are allocated to 12 supply groups.

In general, recruits from high-AFQT-level mission groups qualify for most Army jobs, while the opposite is true for low AFQT level recruits. Consequently, it is harder to assign the low-level recruits in a manner that will contribute gains in overall EPAS efficiency. In this light, we allowed ourselves to be a little liberal by allocating relatively more supply groups in the lower AFQT categories than is reflective of their relative sizes without unnecessarily compromising the overall priorities of the mission groups.

During the first stage of the cluster analysis, a small macro cluster with a verbal principal component score mean that was more than five standard deviations below zero and a quantitative principal component score mean that was two standard deviations above zero was obtained. In addition, this outlier cluster was much less tightly packed than the other clusters. In carrying out the mission group level cluster analyses, the formation of this tiny cluster was allowed so that outlying observations would not skew the overall supply group configurations. However, the clusters corresponding to this outlier macro cluster were dropped at the end of the second stage cluster analysis and excluded from further consideration. These outlier mission level clusters accounted for a total of 114 recruits, less than 0.1 percent of our working sample.

The centroids of the final supply groups are given in Appendices C.1 to C.4. These were computed using four principal components, ASVAB test scores, and AA scores. Note that we derived only two clusters for the Category IV AFQT category, one each for male and female recruits. These were replicated once for each education level for reporting purposes in Appendices C.1 to C.4, thus, the overall total of 150 clusters in these Appendices. A scatter plot of supply group centroids using the quantitative and verbal components is presented in Appendix C.5. The plot symbols correspond to the supply group identification variable CL_ID given in Appendix 1. Observe that the general orientation of centroids suggests that supply groups of the same AFQT level were differentiated along a diagonal axis in the QUANT and VERBAL coordinates. The pattern is not surprising as QUANT and VERBAL are the components used (with equal weights) in the computation of AFQT composite. Recruits of the same AFQT level will more or less fall along a diagonal line oriented in similar fashion as that shown in the plot.

In conclusion, the sizes of supply groups in each mission category were fairly even. This is consistent with the no-structure nature of the mission category distribution of ASVAB scores. The supply groups provide a data reduction mechanism, forming homogeneous groups of recruits rather than depicting a natural cluster structure in the population.

4. MONITORING CHANGES IN THE POPULATION

In this section we describe a strategy by which we can monitor changes in the recruit population that may impact the classification efficiency of the supply groups. Two characteristics of future recruit population that can potentially affect overall performance of supply groups are the location and variability of ASVAB test scores. A shift in the overall location of test scores will impair classification efficiency as the supply groups are no longer optimally centered relative to the new population. A substantial change in test scores variability will have an impact on the homogeneity of the supply groups.

We developed a procedure that will monitor any change in both the mean and variance of the ASVAB test scores in each mission group. We looked at each mission group individually as the final supply groups were formed separately by mission groups. Following this strategy, we only need to reconfigure mission groups where there is substantial change in location and variability of test scores. This may be carried out using the second level cluster analysis discussed in Section 2 applied to the appropriate mission groups using the current number of supply groups and centroids as initial seeds.

The method we present in this section tests the hypothesis that the mean and covariance matrix of ASVAB test scores are equal to a specified mean vector and covariance matrix (Anderson, 1984 pp. 440-442). In monitoring a given mission group, we want to compare the ASVAB mean and covariance of a sample taken from the current mission group population with the mean and covariance of the same mission group computed from the sample upon which the existing subgroups were based.

The mission group specific test statistic we developed is based on the multivariate normal theory. However, as we have noted earlier, the mission groups do not exactly follow the normal distribution. Consequently, we designed a procedure that estimates the actual distribution of the test statistic within each mission group. We regarded the large database of recruits as the reference population. Using predetermined sample sizes, we sampled with replacement from each mission group and computed the value of the test statistic, repeatedly. The associated .05 level critical value of the test statistic for each mission group was approximated using 100,000 replications.

The suggested sample size and corresponding critical value for the monitoring procedure for each mission group are shown in Table 4. The critical values already reflect the adjustments to the theoretical distribution of the test statistic (chi-square with df = 54) made necessary by departure from an exact multivariate normal distribution. A significant change in the location and variability of ASVAB test scores is indicated by a computed test statistic that is larger than the appropriate critical value for the mission group under consideration.

The source and usage description of the Statistical Analysis System (SAS/IML) program implementing the test procedure is given in Appendix C.6. Carrying out the test requires as input a sample of ASVAB test scores from a mission group using the appropriate sample size from Table 4. We also input in the program the mission group's code that identifies the appropriate mission group parameters from a parameter database. We then compare the computed sample test statistic with the corresponding critical value in Table 4. Again, a larger sample statistic indicates a significant difference at the .05-level between the sample mean and covariance and the current parameter values.

Table 4. Monitoring Test Sample Sizes and Critical Values

Sex	AFQT	Education	Group Code	Sample Size	Critical Value
Male	1-3A	H.S. Grad.	1	400	81.36
	1-3A	H.S. Senior	2	400	77.89
	1-3A	Non-Grad.	3	200	81.28
	3B	H.S. Grad.	4	400	77.09
	3B	H.S. Senior	5	400	79.54
	3B	Non-Grad.	6	100	75.22
	4	ALL	7	200	95.14
Female	1-3A	H.S. Grad.	8	400	85.18
	1-3A	H.S. Senior	9	200	83.07
	1-3A	Non-Grad.	10	200	81.57
	3B	H.S. Grad.	11	400	83.91
	3B	H.S. Senior	12	200	78.70
	3B	Non-Grad.	13	50	83.78
	4	ALL	14	50	93.03

We recommend that the magnitude of any statistically significant difference between means and variances of the current sample and the original reference sample of 140,841 recruits be closely examined and assessed for any practical significance. It is possible for the test to identify a statistically significant difference that may not necessarily impact overall EPAS classification efficiency. The actual magnitude of relevant deviations in mean and variance from current parameter values as they influence subsequent EPAS efficiency warrants further study.

5. REFERENCE

Anderson, T.W., *An Introduction to Multivariate Statistical Analysis* (2nd ed.), John Wiley and Sons, New York, 1984.

APPENDIX C.1

Supply Group Principal Components Means

CCLUSTER	CL_ID	SSEX	EDSTAT	AFQT2	QUANT	VERBAL	TECH	SPEED
1	1M1	Male	HSDG	Cat 1-3A	0.12602	-0.13918	-1.15254	0.04767
2	1M2	Male	HSDG	Cat 1-3A	1.43403	-0.71731	0.65490	-0.47734
3	1M3	Male	HSDG	Cat 1-3A	-0.82814	1.38551	0.53494	0.54571
4	1M4	Male	HSDG	Cat 1-3A	-0.00955	0.79847	1.35913	0.90207
5	1M5	Male	HSDG	Cat 1-3A	1.56384	0.09389	1.22942	0.46819
6	1M6	Male	HSDG	Cat 1-3A	0.72939	0.87657	-0.22067	-1.17112
7	1M7	Male	HSDG	Cat 1-3A	0.23009	0.13718	-0.00489	0.25468
8	1M8	Male	HSDG	Cat 1-3A	0.36592	-0.42242	-0.72032	1.16419
9	1M9	Male	HSDG	Cat 1-3A	-0.16399	1.30186	1.28753	-0.67664
10	1M10	Male	HSDG	Cat 1-3A	0.42791	-0.30054	-0.88876	-1.53163
11	1M11	Male	HSDG	Cat 1-3A	1.19260	0.58795	1.33358	-0.87061
12	1M12	Male	HSDG	Cat 1-3A	-0.57676	0.72433	-0.51110	0.96610
13	1M13	Male	HSDG	Cat 1-3A	-0.71189	0.81193	0.89869	-1.10230
14	1M14	Male	HSDG	Cat 1-3A	0.74689	0.98712	-0.60333	0.79290
15	1M15	Male	HSDG	Cat 1-3A	0.16965	-0.06712	-0.19148	0.00892
16	1M16	Male	HSDG	Cat 1-3A	0.10609	0.39154	0.43986	-0.00920
17	1M17	Male	HSDG	Cat 1-3A	1.15784	0.99077	0.27481	0.02331
18	1M18	Male	HSDG	Cat 1-3A	0.24800	-0.20971	0.92997	1.04769
19	1M19	Male	HSDG	Cat 1-3A	1.01576	-1.29000	-0.48704	-0.03871
20	1M20	Male	HSDG	Cat 1-3A	-0.05688	-0.68692	0.54358	0.05777
21	1M21	Male	HSDG	Cat 1-3A	0.08332	-0.30178	1.65001	-0.05742
22	1M22	Male	HSDG	Cat 1-3A	1.01864	1.35904	0.35514	1.27021
23	1M23	Male	HSDG	Cat 1-3A	-0.55606	0.96121	-0.59604	-0.89863
24	1M24	Male	HSDG	Cat 1-3A	1.03737	1.29439	1.34778	0.74086
25	1M25	Male	HSDG	Cat 1-3A	1.52974	-0.04595	-0.11006	0.54085
26	1M26	Male	HSDG	Cat 1-3A	0.36809	-0.28700	0.79631	-1.64971
27	4M1	Male	HSDG	Cat 3B	0.36555	-2.34738	-0.52399	-0.40584
28	4M2	Male	HSDG	Cat 3B	-0.59485	-0.27058	-0.12228	-0.51926
29	4M3	Male	HSDG	Cat 3B	-1.11375	-0.80140	0.40216	0.17248
30	4M4	Male	HSDG	Cat 3B	-1.17483	-0.30947	1.37339	0.69709
31	4M5	Male	HSDG	Cat 3B	-1.29061	0.27641	-0.08673	-1.92874
32	4M6	Male	HSDG	Cat 3B	-1.69973	0.81929	0.05255	0.15137
33	4M7	Male	HSDG	Cat 3B	-0.52313	-1.22292	-0.87848	0.37649
34	4M8	Male	HSDG	Cat 3B	-1.52532	0.47379	1.25002	-0.98194
35	4M9	Male	HSDG	Cat 3B	-0.46081	-1.05798	-0.54535	-1.48206
36	4M10	Male	HSDG	Cat 3B	-1.33301	-0.00782	-0.82622	0.89413
37	4M11	Male	HSDG	Cat 3B	-0.18302	-1.68642	0.43927	0.27394
38	4M12	Male	HSDG	Cat 3B	-0.74623	-0.69503	-0.10870	1.21377
39	4M13	Male	HSDG	Cat 3B	-1.24647	0.05870	-0.88504	-0.68163
40	4M14	Male	HSDG	Cat 3B	-0.66221	-1.05802	1.26310	-0.97883
41	7M2	Male	HSDG	Cat IV	-1.39708	-0.76881	0.19736	-1.53486
42	7M3	Male	HSDG	Cat IV	-2.00932	0.05960	0.03085	0.08346
43	7M4	Male	HSDG	Cat IV	-1.89335	-0.27763	1.27401	-1.05067
44	7M5	Male	HSDG	Cat IV	-1.06466	-1.34768	-0.15180	-0.32043
45	7M6	Male	HSDG	Cat IV	-1.51026	-0.82962	-0.42410	1.07872
46	7M7	Male	HSDG	Cat IV	-0.47181	-2.29041	-0.29041	0.48795
47	7M8	Male	HSDG	Cat IV	-1.18049	-1.46697	1.08356	0.32615
48	2M1	Male	Senior	Cat 1-3A	1.37111	-1.07485	0.65587	-0.47225
49	2M2	Male	Senior	Cat 1-3A	1.00010	0.69199	-0.20813	-0.77280
50	2M3	Male	Senior	Cat 1-3A	0.34946	-0.04808	-0.03600	-0.03635

APPENDIX C.1

Supply Group Principal Components Means

CCLUSTER	CL_ID	SSEX	EDSTAT	AFQT2	QUANT	VERBAL	TECH	SPEED
51	2M4	Male	Senior	Cat 1-3A	0.03113	-0.18333	1.06200	0.51670
52	2M5	Male	Senior	Cat 1-3A	1.49331	0.17039	0.20370	0.47348
53	2M6	Male	Senior	Cat 1-3A	-0.22218	0.76264	-0.25482	-1.45974
54	2M7	Male	Senior	Cat 1-3A	0.82999	1.18282	0.61525	0.75718
55	2M8	Male	Senior	Cat 1-3A	0.44738	-0.58459	-1.11048	0.51521
56	2M9	Male	Senior	Cat 1-3A	-0.17337	1.04992	1.07562	-0.77497
57	2M10	Male	Senior	Cat 1-3A	0.66563	-0.60305	-0.69670	-1.27633
58	2M11	Male	Senior	Cat 1-3A	1.25225	0.31950	1.25937	-0.39100
59	2M12	Male	Senior	Cat 1-3A	-0.42872	1.23941	0.09827	0.32008
60	2M13	Male	Senior	Cat 1-3A	0.98086	-0.83759	-0.22076	0.32721
61	2M14	Male	Senior	Cat 1-3A	0.40929	0.49558	-0.51584	1.08639
62	2M15	Male	Senior	Cat 1-3A	-0.21015	0.47118	-0.90271	-0.01478
63	2M16	Male	Senior	Cat 1-3A	0.40649	-0.23898	0.95091	-1.37055
64	5M1	Male	Senior	Cat 3B	-1.48656	0.80945	-0.21889	0.11566
65	5M2	Male	Senior	Cat 3B	-0.71279	-0.58070	0.55011	0.50158
66	5M3	Male	Senior	Cat 3B	-1.00971	0.06822	-0.00866	-1.78149
67	5M4	Male	Senior	Cat 3B	-0.34645	-1.26142	1.04982	-0.80517
68	5M6	Male	Senior	Cat 3B	-1.23310	0.31330	1.19957	-0.64433
69	5M7	Male	Senior	Cat 3B	-0.21339	-1.15540	-0.53789	-1.05228
70	5M8	Male	Senior	Cat 3B	-0.86969	-0.40657	-0.84220	0.80804
71	5M9	Male	Senior	Cat 3B	-0.04769	-1.71049	-0.45917	0.34089
72	5M10	Male	Senior	Cat 3B	-0.89432	-0.12795	-0.76789	-0.67820
73	7M2	Male	Senior	Cat IV	-1.39708	-0.76881	0.19736	-1.53486
74	7M3	Male	Senior	Cat IV	-2.00932	0.05960	0.03085	0.08346
75	7M4	Male	Senior	Cat IV	-1.89335	-0.27763	1.27401	-1.05067
76	7M5	Male	Senior	Cat IV	-1.06466	-1.34768	-0.15180	-0.32043
77	7M6	Male	Senior	Cat IV	-1.51026	-0.82962	-0.42410	1.07872
78	7M7	Male	Senior	Cat IV	-0.47181	-2.29041	-0.29041	0.48795
79	7M8	Male	Senior	Cat IV	-1.18049	-1.46697	1.08356	0.32615
80	3M2	Male	Non-Grad	Cat 1-3A	-0.17922	-0.28972	1.02757	0.50512
81	3M3	Male	Non-Grad	Cat 1-3A	-0.56238	1.13200	1.10716	0.75364
82	3M4	Male	Non-Grad	Cat 1-3A	-0.46311	0.78794	-0.28853	0.34745
83	3M5	Male	Non-Grad	Cat 1-3A	-0.30615	0.41537	-0.10395	-1.36092
84	3M6	Male	Non-Grad	Cat 1-3A	0.46641	-0.61277	1.14455	-0.96713
85	3M7	Male	Non-Grad	Cat 1-3A	-0.45990	0.89259	1.17170	-0.98129
86	3M8	Male	Non-Grad	Cat 1-3A	1.00417	0.46404	0.93992	0.14683
87	3M9	Male	Non-Grad	Cat 1-3A	0.36863	-0.70608	-0.38925	0.06753
88	6M1	Male	Non-Grad	Cat 3B	-1.02596	-0.37286	1.11120	0.37039
89	6M2	Male	Non-Grad	Cat 3B	-1.37881	0.41850	0.39240	-1.24401
90	6M3	Male	Non-Grad	Cat 3B	-0.93887	-0.36880	-0.52283	0.44106
91	6M4	Male	Non-Grad	Cat 3B	-0.51377	-1.32964	-0.03116	-0.83823
92	7M2	Male	Non-Grad	Cat IV	-1.39708	-0.76881	0.19736	-1.53486
93	7M3	Male	Non-Grad	Cat IV	-2.00932	0.05960	0.03085	0.08346
94	7M4	Male	Non-Grad	Cat IV	-1.89335	-0.27763	1.27401	-1.05067
95	7M5	Male	Non-Grad	Cat IV	-1.06466	-1.34768	-0.15180	-0.32043
96	7M6	Male	Non-Grad	Cat IV	-1.51026	-0.82962	-0.42410	1.07872
97	7M7	Male	Non-Grad	Cat IV	-0.47181	-2.29041	-0.29041	0.48795
98	7M8	Male	Non-Grad	Cat IV	-1.18049	-1.46697	1.08356	0.32615
99	1F1	Female	HSDG	Cat 1-3A	0.03043	-0.30071	-1.42006	0.85484
100	1F2	Female	HSDG	Cat 1-3A	0.79881	0.55143	-1.13571	0.10402

APPENDIX C.1

Supply Group Principal Components Means

CCLUSTER	CL_ID	SSEX	EDSTAT	AFQT2	QUANT	VERBAL	TECH	SPEED
101	1F3	Female	HSDG	Cat 1-3A	-0.18278	0.27765	-0.07873	0.83757
102	1F4	Female	HSDG	Cat 1-3A	1.53079	-0.13341	-0.24445	0.34470
103	1F5	Female	HSDG	Cat 1-3A	-0.32706	0.88166	-0.71579	-0.93701
104	1F6	Female	HSDG	Cat 1-3A	1.05753	1.20830	-0.19894	1.05672
105	1F8	Female	HSDG	Cat 1-3A	0.80355	0.88832	-0.02977	-0.52392
106	1F9	Female	HSDG	Cat 1-3A	0.67549	-0.67660	-0.80246	-0.83656
107	1F10	Female	HSDG	Cat 1-3A	-0.64922	1.15647	-1.20128	0.91150
108	1F11	Female	HSDG	Cat 1-3A	0.88018	-0.99151	-0.93561	0.52454
109	1F12	Female	HSDG	Cat 1-3A	0.52776	0.43090	-1.10797	1.31770
110	1F13	Female	HSDG	Cat 1-3A	-0.17853	0.13974	-1.44825	-0.48042
111	4F1	Female	HSDG	Cat 3B	-1.56912	0.82099	-0.78499	0.54343
112	4F2	Female	HSDG	Cat 3B	-0.62299	-0.58438	-0.29383	0.49785
113	4F3	Female	HSDG	Cat 3B	-1.04163	0.19773	-0.78733	-1.14048
114	4F4	Female	HSDG	Cat 3B	0.13348	-1.96276	-0.82430	0.12381
115	4F5	Female	HSDG	Cat 3B	-0.31582	-0.99762	-1.07044	-0.94417
116	4F6	Female	HSDG	Cat 3B	-1.08243	-0.15678	-1.07904	1.50913
117	4F7	Female	HSDG	Cat 3B	-0.41919	-1.25704	-1.11743	0.98983
118	4F8	Female	HSDG	Cat 3B	-1.00812	-0.29440	-1.24201	0.26534
119	7F1	Female	HSDG	Cat IV	-0.76721	-1.65030	-0.69072	0.75446
120	7F2	Female	HSDG	Cat IV	-1.28855	-0.58912	-0.47002	-0.46752
121	7F3	Female	HSDG	Cat IV	-1.68559	-0.33394	-0.71843	1.20576
122	2F1	Female	Senior	Cat 1-3A	0.35286	-0.14764	-1.26208	0.22178
123	2F2	Female	Senior	Cat 1-3A	0.33799	0.58182	-0.63536	-0.99991
124	2F3	Female	Senior	Cat 1-3A	1.45587	-0.10006	-0.32751	-0.05939
125	2F4	Female	Senior	Cat 1-3A	0.85588	0.83511	-0.66024	0.78821
126	2F6	Female	Senior	Cat 1-3A	0.36707	-0.33050	-1.29018	-1.23572
127	2F7	Female	Senior	Cat 1-3A	0.01614	0.14487	-1.31327	1.22198
128	2F8	Female	Senior	Cat 1-3A	0.93223	-1.04018	-0.94953	0.33865
129	2F9	Female	Senior	Cat 1-3A	-0.40952	1.07057	-1.16422	0.09793
130	5F2	Female	Senior	Cat 3B	-0.39647	-0.61397	-0.33692	0.37311
131	5F3	Female	Senior	Cat 3B	-0.83962	0.28374	-1.02375	-1.17603
132	5F4	Female	Senior	Cat 3B	-1.27167	0.54201	-0.97701	0.65122
133	5F5	Female	Senior	Cat 3B	-0.05439	-1.26735	-0.91731	-0.94535
134	5F6	Female	Senior	Cat 3B	-0.83133	-0.37315	-1.10637	1.43707
135	5F7	Female	Senior	Cat 3B	-0.02844	-1.61982	-0.95360	0.67055
136	5F8	Female	Senior	Cat 3B	-0.63432	-0.45726	-1.34614	0.16769
137	7F1	Female	Senior	Cat IV	-0.76721	-1.65030	-0.69072	0.75446
138	7F2	Female	Senior	Cat IV	-1.28855	-0.58912	-0.47002	-0.46752
139	7F3	Female	Senior	Cat IV	-1.68559	-0.33394	-0.71843	1.20576
140	3F1	Female	Non-Grad	Cat 1-3A	-0.40349	0.77970	-0.99686	1.11378
141	3F2	Female	Non-Grad	Cat 1-3A	-0.51501	0.86272	-0.61432	-0.95377
142	3F3	Female	Non-Grad	Cat 1-3A	-0.26280	0.03005	-0.08226	0.54699
143	3F4	Female	Non-Grad	Cat 1-3A	0.88158	0.42057	0.06787	0.45046
144	3F5	Female	Non-Grad	Cat 1-3A	0.43512	-0.58702	-1.04571	-0.05820
145	6F1	Female	Non-Grad	Cat 3B	-0.51671	-0.81412	-0.79051	1.03141
146	6F2	Female	Non-Grad	Cat 3B	-0.90539	-0.46245	-0.72017	-0.47187
147	6F3	Female	Non-Grad	Cat 3B	-1.42109	0.61595	-0.42332	-0.05210
148	7F1	Female	Non-Grad	Cat IV	-0.76721	-1.65030	-0.69072	0.75446
149	7F2	Female	Non-Grad	Cat IV	-1.28855	-0.58912	-0.47002	-0.46752
150	7F3	Female	Non-Grad	Cat IV	-1.68559	-0.33394	-0.71843	1.20576

APPENDIX C.2

Supply Group ASVAB Means

CCLUSTER	CL_ID	SSEX	EDSTAT	AFQT2	GS	AR	NO	CS	AS	MK	MC	EI	VE
1	1M1	Male	HSDG	Cat 1-3A	50.1523	50.6947	57.1013	52.2901	42.4298	54.3947	42.3086	44.3086	53.6735
2	1M2	Male	HSDG	Cat 1-3A	56.9050	60.7352	57.0562	45.4745	54.9061	62.8250	60.5504	48.6622	50.8864
3	1M3	Male	HSDG	Cat 1-3A	53.8276	50.0533	53.4871	61.0527	53.1586	48.7708	55.6541	61.6272	60.8498
4	1M4	Male	HSDG	Cat 1-3A	57.5458	56.4407	58.2435	60.7216	61.0333	54.6655	60.5619	60.6629	58.7055
5	1M5	Male	HSDG	Cat 1-3A	61.9890	63.8478	60.7391	54.8584	60.8571	65.2097	64.1949	55.7628	55.7019
6	1M6	Male	HSDG	Cat 1-3A	57.5549	55.8228	46.0132	50.0473	48.5132	58.8178	57.2636	55.2768	57.0296
7	1M7	Male	HSDG	Cat 1-3A	55.4123	51.7199	57.4720	55.1419	47.7436	54.1127	57.4683	48.4440	54.7357
8	1M8	Male	HSDG	Cat 1-3A	46.7397	56.5400	60.2774	61.8796	43.6278	57.8982	48.1453	44.0218	51.8407
9	1M9	Male	HSDG	Cat 1-3A	59.2857	53.4733	47.0217	52.9724	61.0402	53.4022	61.9309	64.2535	59.6893
10	1M10	Male	HSDG	Cat 1-3A	50.3525	52.6090	46.0869	43.3516	44.8008	55.9164	47.2607	43.7828	51.5762
11	1M11	Male	HSDG	Cat 1-3A	62.1237	61.0644	50.8394	47.7068	62.3956	62.4986	64.6928	60.4275	57.3089
12	1M12	Male	HSDG	Cat 1-3A	49.6362	50.5282	57.5993	62.3268	45.5758	50.7758	46.7134	53.4342	57.5389
13	1M13	Male	HSDG	Cat 1-3A	53.7628	50.3884	43.4675	49.5962	57.7950	48.0973	57.7537	57.2393	57.1770
14	1M14	Male	HSDG	Cat 1-3A	56.7211	58.1603	58.6649	62.1887	45.6406	59.8281	51.1777	55.6574	58.9161
15	1M15	Male	HSDG	Cat 1-3A	46.1126	54.6825	53.6986	52.7056	45.2797	57.0490	53.7797	53.3643	52.7986
16	1M16	Male	HSDG	Cat 1-3A	57.7271	52.3650	56.8997	51.6012	55.3429	54.5563	51.2216	56.2367	55.8373
17	1M17	Male	HSDG	Cat 1-3A	60.1446	60.2180	56.0369	55.0521	50.8919	61.8285	61.6795	59.7065	59.4095
18	1M18	Male	HSDG	Cat 1-3A	49.8218	58.2471	59.4590	59.4900	56.3335	57.8865	58.3449	53.4215	53.5046
19	1M19	Male	HSDG	Cat 1-3A	49.5303	57.0451	58.8831	48.3852	45.3366	60.2134	51.0500	39.5444	47.5042
20	1M20	Male	HSDG	Cat 1-3A	49.7129	54.1879	56.1973	50.1217	55.8471	52.8327	51.1754	46.2953	51.4763
21	1M21	Male	HSDG	Cat 1-3A	54.6117	56.3528	55.1253	49.8455	62.7552	53.5600	61.7886	54.1686	52.9462
22	1M22	Male	HSDG	Cat 1-3A	60.4775	61.7892	59.8611	67.3326	52.3305	62.6931	61.3981	60.8332	61.2237
23	1M23	Male	HSDG	Cat 1-3A	52.3504	48.5571	46.2004	51.2978	46.7680	49.2474	47.1570	53.4513	57.9243
24	1M24	Male	HSDG	Cat 1-3A	63.0513	62.4496	58.1563	61.2817	61.7364	63.1101	64.9870	65.5698	61.3955
25	1M25	Male	HSDG	Cat 1-3A	58.2756	62.1315	60.6679	56.8923	49.1510	63.8527	57.5100	48.2534	54.4287
26	1M26	Male	HSDG	Cat 1-3A	55.9719	53.3495	47.1939	39.6582	57.6207	54.8444	57.4974	51.0731	52.0383
27	4M1	Male	HSDG	Cat 3B	43.6621	51.4890	56.8616	43.2353	43.7036	56.2272	45.5975	35.1569	39.2872
28	4M2	Male	HSDG	Cat 3B	49.6719	45.8192	50.7920	49.7932	45.1323	49.5540	52.2311	50.1941	48.9417
29	4M3	Male	HSDG	Cat 3B	46.3161	46.2902	55.4412	50.9320	53.5032	45.9585	45.5458	46.6413	48.7540
30	4M4	Male	HSDG	Cat 3B	49.1193	48.0024	56.2558	56.5605	58.0567	46.4099	55.9900	55.0195	50.3024
31	4M5	Male	HSDG	Cat 3B	49.4606	42.5986	38.7707	43.6077	50.6355	44.1387	46.9756	50.8878	52.0969
32	4M6	Male	HSDG	Cat 3B	48.7996	42.3550	50.3075	57.8597	48.6274	42.6080	48.0338	56.8046	55.5748
33	4M7	Male	HSDG	Cat 3B	42.6729	46.9308	57.5764	52.7752	41.2281	51.0384	42.1931	39.7805	45.7877
34	4M8	Male	HSDG	Cat 3B	51.3504	44.4144	43.4373	49.3699	59.0822	43.1934	56.1732	58.1900	53.4798
35	4M9	Male	HSDG	Cat 3B	45.5097	46.5491	45.7286	41.6929	45.4859	49.6635	46.0650	40.3377	46.0957
36	4M10	Male	HSDG	Cat 3B	44.5516	43.2408	57.3227	60.1179	41.4880	45.5614	41.5982	47.7260	52.0636
37	4M11	Male	HSDG	Cat 3B	44.9236	51.1317	57.6699	50.0806	49.4632	52.9138	53.3630	42.6699	42.8823
38	4M12	Male	HSDG	Cat 3B	43.9027	48.6776	58.8436	61.6275	44.5608	50.9277	49.6108	47.9256	47.1001
39	4M13	Male	HSDG	Cat 3B	44.3438	43.2957	46.3634	51.4097	42.2743	45.4774	42.8831	47.0787	51.6672
40	4M14	Male	HSDG	Cat 3B	49.2072	48.5558	48.7202	43.1148	58.9237	48.6458	55.9758	48.5831	46.2140
41	7M2	Male	HSDG	Cat IV	44.9902	42.1063	41.4508	43.7992	51.0669	44.1909	47.6142	45.6713	45.6969
42	7M3	Male	HSDG	Cat IV	43.9376	40.1583	49.6560	55.7732	47.3577	41.1187	45.4460	53.1309	50.2603
43	7M4	Male	HSDG	Cat IV	46.7174	41.1884	42.6836	47.4203	58.4275	41.9058	53.3502	54.9855	47.9614
44	7M5	Male	HSDG	Cat IV	43.4006	43.8104	53.0642	47.2217	45.3853	45.5336	46.3547	41.9052	43.8578
45	7M6	Male	HSDG	Cat IV	41.0787	42.4650	57.8994	59.9694	42.7536	45.2070	43.2726	45.0160	46.1983
46	7M7	Male	HSDG	Cat IV	40.1213	47.6989	58.2292	51.6404	43.4966	52.1416	45.4809	36.9663	37.8966
47	7M8	Male	HSDG	Cat IV	45.0665	45.4254	55.6593	51.3367	55.2500	46.7238	51.8468	47.2198	42.6290
48	2M1	Male	Senior	Cat 1-3A	56.5273	59.2900	58.0847	44.2373	55.0584	62.2524	59.1893	46.0179	48.7957
49	2M2	Male	Senior	Cat 1-3A	58.3505	56.8141	51.0587	50.1795	46.9406	60.2647	58.7198	55.4829	56.4913
50	2M3	Male	Senior	Cat 1-3A	56.9396	52.2352	57.7122	51.1005	51.4001	55.6728	49.5013	49.9481	53.3844

APPENDIX C.2

Supply Group ASVAB Means

CCLUSTER	CL_ID	SSEX	EDSTAT	AFQT2	GS	AR	NO	CS	AS	MK	MC	EI	VE
51	2M4	Male	Senior	Cat 1-3A	51.9141	54.1551	57.4747	55.2138	57.1267	55.7942	59.2930	53.9302	53.0630
52	2M5	Male	Senior	Cat 1-3A	59.5515	61.8212	60.4014	56.2697	50.4816	63.7704	60.7385	52.3060	55.2411
53	2M6	Male	Senior	Cat 1-3A	53.8734	49.5789	43.0518	47.6406	49.1604	52.0551	51.7048	53.8363	56.0822
54	2M7	Male	Senior	Cat 1-3A	60.2436	59.6629	58.2188	61.6501	53.9901	61.0652	61.5205	62.4426	59.9108
55	2M8	Male	Senior	Cat 1-3A	48.8818	54.3438	59.2852	55.6895	41.8740	56.6934	43.9727	40.9531	51.0068
56	2M9	Male	Senior	Cat 1-3A	58.7470	51.4451	47.3984	51.5233	59.2870	53.5763	60.3059	61.7834	58.0451
57	2M10	Male	Senior	Cat 1-3A	52.0009	53.0219	49.9412	42.9360	45.6061	57.1360	49.2728	42.4316	50.3342
58	2M11	Male	Senior	Cat 1-3A	61.5152	60.9426	54.8899	49.5631	60.8474	63.0520	64.1499	58.8710	55.9217
59	2M12	Male	Senior	Cat 1-3A	55.7518	49.5478	54.1624	59.0653	49.3224	51.3976	54.7127	59.6269	59.3673
60	2M13	Male	Senior	Cat 1-3A	51.3650	57.5614	59.3643	53.1179	46.1407	60.2993	55.9036	42.9279	49.7057
61	2M14	Male	Senior	Cat 1-3A	52.7651	55.9783	59.3667	63.7783	44.5713	58.1101	51.9643	52.2264	55.7550
62	2M15	Male	Senior	Cat 1-3A	49.1761	49.8739	53.5250	54.6852	41.6646	52.9667	47.3664	51.2078	55.7042
63	2M16	Male	Senior	Cat 1-3A	55.8378	54.0890	47.3087	43.1181	58.1039	56.0575	60.2512	51.6858	51.8354
64	5M1	Male	Senior	Cat 3B	49.5325	41.9126	50.7859	57.8072	46.3206	44.7276	47.3397	56.4518	55.0426
65	5M2	Male	Senior	Cat 3B	48.8264	47.2700	56.9888	54.8825	51.2898	50.1637	52.8244	50.6937	48.3406
66	5M3	Male	Senior	Cat 3B	50.7013	43.7236	40.9341	43.6800	50.2950	45.8859	48.9889	50.2282	50.7607
67	5M4	Male	Senior	Cat 3B	49.5580	49.1318	50.4242	44.3221	56.8920	51.5996	55.9752	46.7344	44.7086
68	5M6	Male	Senior	Cat 3B	52.7947	44.4868	46.9360	50.8852	58.2673	46.0488	56.7703	57.5915	52.4268
69	5M7	Male	Senior	Cat 3B	48.9360	46.3918	51.0649	42.7967	45.6450	51.1578	45.2831	40.4233	45.5995
70	5M8	Male	Senior	Cat 3B	46.0066	44.9615	58.4505	58.5504	41.2523	48.5487	42.8231	44.9197	49.6495
71	5M9	Male	Senior	Cat 3B	43.9596	50.0994	58.4061	51.4204	43.3361	54.1120	47.2300	38.5232	42.6344
72	5M10	Male	Senior	Cat 3B	45.6845	44.5567	47.4361	50.8578	42.2995	48.1613	45.8187	46.8802	50.3203
73	7M2	Male	Senior	Cat IV	44.9902	42.1063	41.4508	43.7992	51.0669	44.1909	47.6142	45.6713	45.6969
74	7M3	Male	Senior	Cat IV	43.9376	40.1583	49.6560	55.7732	47.3577	41.1187	45.4460	53.1309	50.2603
75	7M4	Male	Senior	Cat IV	46.7174	41.1884	42.6836	47.4203	58.4275	41.9058	53.3502	54.9855	47.9614
76	7M5	Male	Senior	Cat IV	43.4006	43.8104	53.0642	47.2217	45.3853	45.5336	46.3547	41.9052	43.8578
77	7M6	Male	Senior	Cat IV	41.0787	42.4650	57.8994	59.9694	42.7536	45.2070	43.2726	45.0160	46.1983
78	7M7	Male	Senior	Cat IV	40.1213	47.6989	58.2292	51.6404	43.4966	52.1416	45.4809	36.9663	37.8966
79	7M8	Male	Senior	Cat IV	45.0665	45.4254	55.6593	51.3367	55.2500	46.7238	51.8468	47.2198	42.6290
80	3M2	Male	Non-Grad	Cat 1-3A	50.4061	55.9116	57.3718	54.1652	56.8845	51.6661	57.2356	51.9025	53.2392
81	3M3	Male	Non-Grad	Cat 1-3A	55.6045	53.7898	55.5637	61.1248	57.5756	49.6544	59.2589	61.8357	59.8804
82	3M4	Male	Non-Grad	Cat 1-3A	51.7335	51.5832	54.5862	57.7996	47.0170	49.6232	49.8226	54.0110	57.9479
83	3M5	Male	Non-Grad	Cat 1-3A	51.6394	51.2576	44.4121	46.1624	49.7100	49.6013	52.2744	50.8331	55.4815
84	3M6	Male	Non-Grad	Cat 1-3A	54.4953	56.9988	51.2407	43.0337	58.9616	54.8512	60.2174	49.9663	50.9326
85	3M7	Male	Non-Grad	Cat 1-3A	56.4615	52.2719	45.4632	49.5350	59.6723	49.5004	59.9584	59.8751	57.6563
86	3M8	Male	Non-Grad	Cat 1-3A	59.6394	61.2303	57.0010	54.0000	57.3292	60.2740	62.2217	57.6622	57.0295
87	3M9	Male	Non-Grad	Cat 1-3A	49.0097	55.7685	57.1503	50.7867	46.4909	54.5697	49.4133	42.9564	50.9103
88	6M1	Male	Non-Grad	Cat 3B	49.1105	48.1934	54.9613	54.2044	56.5083	46.6796	55.2652	52.3370	50.4917
89	6M2	Male	Non-Grad	Cat 3B	49.4031	44.8469	42.1071	48.1020	52.3469	43.0765	51.6173	53.9235	53.2551
90	6M3	Male	Non-Grad	Cat 3B	45.7249	45.8297	55.9913	55.6769	43.0655	47.0524	45.9738	46.2271	50.1354
91	6M4	Male	Non-Grad	Cat 3B	45.3036	48.7619	50.3333	43.9702	48.6905	48.3750	48.1190	40.4048	45.3750
92	7M2	Male	Non-Grad	Cat IV	44.9902	42.1063	41.4508	43.7992	51.0669	44.1909	47.6142	45.6713	45.6969
93	7M3	Male	Non-Grad	Cat IV	43.9376	40.1583	49.6560	55.7732	47.3577	41.1187	45.4460	53.1309	50.2603
94	7M4	Male	Non-Grad	Cat IV	46.7174	41.1884	42.6836	47.4203	58.4275	41.9058	53.3502	54.9855	47.9614
95	7M5	Male	Non-Grad	Cat IV	43.4006	43.8104	53.0642	47.2217	45.3853	45.5336	46.3547	41.9052	43.8578
96	7M6	Male	Non-Grad	Cat IV	41.0787	42.4650	57.8994	59.9694	42.7536	45.2070	43.2726	45.0160	46.1983
97	7M7	Male	Non-Grad	Cat IV	40.1213	47.6989	58.2292	51.6404	43.4966	52.1416	45.4809	36.9663	37.8966
98	7M8	Male	Non-Grad	Cat IV	45.0665	45.4254	55.6593	51.3367	55.2500	46.7238	51.8468	47.2198	42.6290
99	1F1	Female	HSDG	Cat 1-3A	46.9638	50.2773	59.8319	59.5171	39.6936	55.5068	41.5029	40.9282	52.7266
100	1F2	Female	HSDG	Cat 1-3A	56.3635	55.4301	57.4942	55.0337	43.0354	59.1143	45.2451	50.3651	56.8191

APPENDIX C.2

Supply Group ASVAB Means

CCLUSTER	CL_ID	SSEX	EDSTAT	AFQT2	GS	AR	NO	CS	AS	MK	MC	EI	VE
101	1F3	Female	HSDG	Cat 1-3A	51.4989	52.8881	58.6018	59.7648	48.6304	52.0992	52.1202	49.7062	56.0834
102	1F4	Female	HSDG	Cat 1-3A	57.7990	61.2375	60.2327	54.8904	48.4758	63.5790	56.7236	46.3709	54.5163
103	1F5	Female	HSDG	Cat 1-3A	53.0535	49.0535	46.1273	51.6503	45.3487	50.5219	49.2631	50.8642	57.6396
104	1F6	Female	HSDG	Cat 1-3A	59.7478	60.6974	59.5151	65.5346	49.0980	62.2414	56.9280	56.4215	60.8271
105	1F8	Female	HSDG	Cat 1-3A	58.5460	57.1865	51.4172	52.6871	50.4969	58.8025	57.8417	54.7693	58.9558
106	1F9	Female	HSDG	Cat 1-3A	52.5090	52.2347	54.5325	44.1046	44.6777	56.6626	48.2771	40.7201	51.0933
107	1F10	Female	HSDG	Cat 1-3A	50.4489	48.2835	56.6532	64.1907	40.6675	50.2034	43.1696	52.6861	59.6143
108	1F11	Female	HSDG	Cat 1-3A	49.1442	56.2127	60.4803	54.7284	42.8421	60.0878	47.6342	38.0991	49.2885
109	1F12	Female	HSDG	Cat 1-3A	51.5373	56.0715	60.1574	66.6795	41.4827	59.3735	47.9751	47.1663	56.0739
110	1F13	Female	HSDG	Cat 1-3A	47.0124	49.7529	50.3812	52.0532	40.4496	52.5038	41.7462	43.3365	54.9278
111	4F1	Female	HSDG	Cat 3B	47.7431	41.9434	53.2666	60.9530	42.2818	43.2887	43.2348	52.3674	56.1561
112	4F2	Female	HSDG	Cat 3B	48.9571	46.7473	57.7737	55.4605	45.2449	48.7063	48.3512	44.3317	49.0400
113	4F3	Female	HSDG	Cat 3B	47.9640	43.8285	43.5228	49.7552	43.8990	45.8326	45.2573	46.3264	52.1480
114	4F4	Female	HSDG	Cat 3B	44.9208	48.8209	59.6688	48.1949	42.0539	54.7385	43.6181	34.2250	42.1109
115	4F5	Female	HSDG	Cat 3B	46.5203	45.5140	51.0444	44.3185	41.4365	50.7627	42.3642	38.9848	46.9734
116	4F6	Female	HSDG	Cat 3B	44.3044	44.9557	59.4227	66.5695	39.3074	48.3645	41.5498	44.5754	50.5616
117	4F7	Female	HSDG	Cat 3B	42.2465	47.1847	60.0122	58.7117	39.3763	53.1533	41.4721	37.7692	45.2657
118	4F8	Female	HSDG	Cat 3B	44.6182	43.5427	55.3054	54.9105	39.4146	46.7562	39.6757	42.6461	51.2061
119	7F1	Female	HSDG	Cat IV	41.7857	44.5000	60.0143	54.4429	41.9286	49.8143	42.0714	37.4429	42.8000
120	7F2	Female	HSDG	Cat IV	46.1692	40.9231	51.1077	49.0000	43.3538	43.7846	45.4462	44.7692	47.6462
121	7F3	Female	HSDG	Cat IV	42.1429	41.3077	57.5714	62.8022	40.7253	43.8462	41.4176	46.8022	48.6593
122	2F1	Female	Senior	Cat 1-3A	52.0602	50.4421	59.0949	53.5243	41.1215	56.3113	43.0058	44.0729	53.2338
123	2F2	Female	Senior	Cat 1-3A	54.7581	51.4191	47.2913	50.6082	45.0239	56.0017	53.6678	49.8535	55.7376
124	2F3	Female	Senior	Cat 1-3A	58.4245	59.0143	58.7854	51.5024	47.2305	62.8299	56.4006	47.4928	54.0588
125	2F4	Female	Senior	Cat 1-3A	56.6288	57.5514	58.7037	62.5187	44.1741	60.4474	54.0242	52.6433	58.2600
126	2F6	Female	Senior	Cat 1-3A	50.0446	50.2107	48.5464	45.3054	41.9268	55.7768	44.8482	40.5571	51.9679
127	2F7	Female	Senior	Cat 1-3A	48.2966	51.2319	59.6768	64.9810	39.2446	56.0089	44.8314	44.4791	54.1774
128	2F8	Female	Senior	Cat 1-3A	49.7897	55.4026	59.8846	53.3205	42.3282	60.2372	48.7449	37.4321	48.8654
129	2F9	Female	Senior	Cat 1-3A	51.9775	47.5345	53.0369	58.1477	41.0963	51.7319	45.1637	52.5602	58.8122
130	5F2	Female	Senior	Cat 3B	48.8320	46.0271	57.0108	55.1924	43.2575	51.7182	51.9458	44.9756	48.1762
131	5F3	Female	Senior	Cat 3B	49.9081	43.0529	44.4735	49.5460	41.5933	47.3426	45.1309	46.6936	52.1142
132	5F4	Female	Senior	Cat 3B	47.1662	42.7292	55.3446	60.4123	39.6831	45.7846	43.1877	51.3262	54.3538
133	5F5	Female	Senior	Cat 3B	47.3018	46.4734	51.2722	44.3521	42.3905	52.9379	44.9172	37.1864	45.2219
134	5F6	Female	Senior	Cat 3B	45.0820	45.1005	59.9127	65.6164	39.8307	50.8042	41.4048	42.9286	49.3757
135	5F7	Female	Senior	Cat 3B	44.2039	48.8750	60.6360	54.2763	40.8399	55.0044	42.4430	36.7675	43.2895
136	5F8	Female	Senior	Cat 3B	46.7200	43.0000	56.2840	53.8740	38.7320	50.2840	40.4040	41.6160	49.8580
137	7F1	Female	Senior	Cat IV	41.7857	44.5000	60.0143	54.4429	41.9286	49.8143	42.0714	37.4429	42.8000
138	7F2	Female	Senior	Cat IV	46.1692	40.9231	51.1077	49.0000	43.3538	43.7846	45.4462	44.7692	47.6462
139	7F3	Female	Senior	Cat IV	42.1429	41.3077	57.5714	62.8022	40.7253	43.8462	41.4176	46.8022	48.6593
140	3F1	Female	Non-Grad	Cat 1-3A	49.2427	52.2136	57.9175	64.6748	41.4320	50.9854	45.4709	50.5146	57.9612
141	3F2	Female	Non-Grad	Cat 1-3A	51.4596	49.4495	45.6414	51.0303	45.6818	48.3131	49.7121	50.6212	58.1010
142	3F3	Female	Non-Grad	Cat 1-3A	50.5699	53.6062	57.7720	56.1554	49.1606	49.7668	50.0725	47.5492	55.2642
143	3F4	Female	Non-Grad	Cat 1-3A	56.6302	60.0781	58.0625	57.2500	50.1406	58.7813	57.3385	52.0729	57.0990
144	3F5	Female	Non-Grad	Cat 1-3A	49.5368	53.7143	56.8485	50.9004	42.5671	55.2554	45.1342	40.1775	51.5931
145	6F1	Female	Non-Grad	Cat 3B	45.3143	48.4571	59.8286	59.9143	41.0857	49.9143	46.0571	39.5714	48.3714
146	6F2	Female	Non-Grad	Cat 3B	46.3750	44.9750	51.2750	49.2750	44.3250	45.9500	43.2750	42.1250	50.5500
147	6F3	Female	Non-Grad	Cat 3B	47.9412	42.9412	50.2647	55.9118	44.9706	43.9412	46.5294	52.6765	55.0588
148	7F1	Female	Non-Grad	Cat IV	41.7857	44.5000	60.0143	54.4429	41.9286	49.8143	42.0714	37.4429	42.8000
149	7F2	Female	Non-Grad	Cat IV	46.1692	40.9231	51.1077	49.0000	43.3538	43.7846	45.4462	44.7692	47.6462
150	7F3	Female	Non-Grad	Cat IV	42.1429	41.3077	57.5714	62.8022	40.7253	43.8462	41.4176	46.8022	48.6593

APPENDIX C.3

Supply Group AA Means

CCLUSTER	CL_ID	SSEX	EDSTAT	AFQT2	GM	EL	CL	MM	SC	CO	FA	OF	ST
1	1M1	Male	HSDG	Cat 1-3A	95.238	100.077	106.685	91.803	93.893	92.583	100.059	97.465	100.607
2	1M2	Male	HSDG	Cat 1-3A	113.952	116.790	118.250	113.191	116.215	113.962	118.127	114.748	118.209
3	1M3	Male	HSDG	Cat 1-3A	110.516	108.408	107.328	114.821	111.916	112.779	109.645	114.634	111.284
4	1M4	Male	HSDG	Cat 1-3A	120.149	116.900	114.777	124.960	121.890	124.648	119.869	124.149	118.370
5	1M5	Male	HSDG	Cat 1-3A	125.953	126.785	125.782	125.619	126.475	127.840	129.282	125.960	127.368
6	1M6	Male	HSDG	Cat 1-3A	112.129	115.864	116.141	104.576	111.263	107.604	113.512	105.712	117.910
7	1M7	Male	HSDG	Cat 1-3A	103.699	105.811	108.022	107.050	107.165	107.876	111.371	111.049	112.806
8	1M8	Male	HSDG	Cat 1-3A	95.824	103.263	112.192	97.869	100.395	106.689	115.033	102.653	102.974
9	1M9	Male	HSDG	Cat 1-3A	122.539	117.525	112.394	121.132	121.538	118.773	113.423	118.678	119.991
10	1M10	Male	HSDG	Cat 1-3A	97.329	101.837	107.691	89.235	98.078	92.786	99.718	93.895	103.252
11	1M11	Male	HSDG	Cat 1-3A	128.081	126.401	122.915	123.652	126.976	122.857	121.994	122.089	127.082
12	1M12	Male	HSDG	Cat 1-3A	100.021	102.811	106.723	102.277	100.526	103.497	106.490	104.854	102.987
13	1M13	Male	HSDG	Cat 1-3A	110.227	105.698	104.407	110.159	113.898	110.032	103.749	110.309	109.966
14	1M14	Male	HSDG	Cat 1-3A	110.786	117.494	119.963	107.053	108.486	111.064	119.241	109.185	115.606
15	1M15	Male	HSDG	Cat 1-3A	101.406	106.671	110.896	103.990	104.150	104.341	111.239	103.692	105.920
16	1M16	Male	HSDG	Cat 1-3A	114.296	112.135	109.612	112.278	108.988	106.900	106.100	112.220	111.441
17	1M17	Male	HSDG	Cat 1-3A	119.367	124.013	123.305	117.503	119.232	117.809	123.711	117.637	125.020
18	1M18	Male	HSDG	Cat 1-3A	110.559	111.287	114.656	117.051	115.842	120.690	120.795	117.398	111.556
19	1M19	Male	HSDG	Cat 1-3A	97.187	103.911	111.135	97.123	100.832	101.465	110.301	101.939	105.102
20	1M20	Male	HSDG	Cat 1-3A	103.088	102.037	106.519	106.088	107.753	107.427	105.229	109.345	103.311
21	1M21	Male	HSDG	Cat 1-3A	114.999	110.890	109.711	120.900	120.184	119.647	113.257	120.466	113.481
22	1M22	Male	HSDG	Cat 1-3A	121.571	126.219	126.414	121.229	121.896	127.219	132.383	121.843	126.600
23	1M23	Male	HSDG	Cat 1-3A	101.418	102.374	104.444	96.327	100.547	96.375	98.008	99.054	104.156
24	1M24	Male	HSDG	Cat 1-3A	131.634	130.957	127.333	131.028	130.000	132.023	131.546	128.978	130.507
25	1M25	Male	HSDG	Cat 1-3A	111.767	118.700	122.591	109.775	113.946	116.464	124.653	113.727	119.871
26	1M26	Male	HSDG	Cat 1-3A	111.745	108.955	107.802	108.435	112.342	105.424	103.449	109.132	112.023
27	4M1	Male	HSDG	Cat 3B	87.884	92.717	98.119	88.874	88.562	90.293	98.155	91.240	91.563
28	4M2	Male	HSDG	Cat 3B	97.147	97.640	96.092	99.255	95.670	95.880	98.672	98.447	100.523
29	4M3	Male	HSDG	Cat 3B	95.900	91.967	93.671	100.967	96.827	97.963	93.471	102.240	92.587
30	4M4	Male	HSDG	Cat 3B	105.387	99.514	96.385	115.693	107.567	111.970	104.429	113.035	101.348
31	4M5	Male	HSDG	Cat 3B	97.479	93.028	92.069	92.486	95.780	90.115	86.626	93.141	96.079
32	4M6	Male	HSDG	Cat 3B	98.513	95.008	93.290	102.554	97.133	98.304	94.782	101.837	97.413
33	4M7	Male	HSDG	Cat 3B	85.543	89.267	95.682	88.524	86.269	89.690	95.993	92.090	89.787
34	4M8	Male	HSDG	Cat 3B	107.265	98.717	93.716	110.561	108.036	105.952	96.138	107.801	102.717
35	4M9	Male	HSDG	Cat 3B	89.207	90.178	94.648	86.598	90.991	87.602	90.610	89.971	93.024
36	4M10	Male	HSDG	Cat 3B	88.234	89.634	93.539	93.005	87.604	91.754	94.573	95.614	90.968
37	4M11	Male	HSDG	Cat 3B	94.460	95.604	98.053	102.217	98.434	102.854	104.727	102.321	96.897
38	4M12	Male	HSDG	Cat 3B	92.914	95.487	97.823	100.839	94.393	103.093	106.773	100.321	95.428
39	4M13	Male	HSDG	Cat 3B	88.139	89.146	93.243	87.179	88.622	87.605	90.097	89.886	91.310
40	4M14	Male	HSDG	Cat 3B	103.475	97.493	95.476	107.727	105.975	104.447	97.999	106.321	100.337
41	7M2	Male	HSDG	Cat IV	92.093	87.307	87.065	91.591	92.335	90.610	86.854	91.514	90.244
42	7M3	Male	HSDG	Cat IV	91.886	88.102	86.670	97.566	90.447	93.192	89.752	95.767	89.253
43	7M4	Male	HSDG	Cat IV	101.531	91.732	86.341	106.022	100.850	100.529	90.565	101.771	94.493
44	7M5	Male	HSDG	Cat IV	86.419	86.009	87.954	92.161	88.171	89.472	89.980	93.243	88.332
45	7M6	Male	HSDG	Cat IV	85.146	85.504	88.439	93.504	85.418	93.017	94.797	94.165	86.385
46	7M7	Male	HSDG	Cat IV	84.375	87.285	91.308	90.616	85.342	92.982	98.404	91.040	86.344
47	7M8	Male	HSDG	Cat IV	96.974	91.522	89.129	106.347	97.438	102.732	97.429	103.567	92.413
48	2M1	Male	Senior	Cat 1-3A	111.940	113.937	115.221	111.482	113.421	111.502	115.318	113.337	115.695
49	2M2	Male	Senior	Cat 1-3A	112.642	117.806	117.542	107.702	111.458	108.234	115.961	108.435	119.720
50	2M3	Male	Senior	Cat 1-3A	108.507	108.692	108.544	105.499	104.133	102.944	105.346	107.666	109.238

APPENDIX C.3

Supply Group AA Means

CCLUSTER	CL_ID	SSEX	EDSTAT	AFQT2	GM	EL	CL	MM	SC	CO	FA	OF	ST
51	2M4	Male	Senior	Cat 1-3A	111.322	109.264	109.805	117.210	114.200	116.507	115.032	116.969	111.848
52	2M5	Male	Senior	Cat 1-3A	115.601	121.492	122.876	114.850	116.931	118.736	125.996	116.906	122.863
53	2M6	Male	Senior	Cat 1-3A	105.578	105.618	105.928	98.887	104.145	99.077	100.840	100.256	108.202
54	2M7	Male	Senior	Cat 1-3A	122.408	124.876	122.699	122.303	120.927	123.425	126.800	121.114	124.840
55	2M8	Male	Senior	Cat 1-3A	93.543	100.822	109.093	91.766	95.128	97.701	106.682	97.857	100.624
56	2M9	Male	Senior	Cat 1-3A	119.853	114.779	109.820	117.789	117.404	114.464	110.435	115.787	117.915
57	2M10	Male	Senior	Cat 1-3A	98.692	102.924	107.976	92.487	99.262	94.560	101.643	97.248	105.354
58	2M11	Male	Senior	Cat 1-3A	126.224	125.411	122.205	123.905	124.872	122.639	123.050	122.451	125.940
59	2M12	Male	Senior	Cat 1-3A	109.771	109.558	107.792	111.113	107.935	108.197	109.152	111.167	112.502
60	2M13	Male	Senior	Cat 1-3A	100.778	107.201	113.170	102.929	105.774	108.297	116.493	107.108	110.252
61	2M14	Male	Senior	Cat 1-3A	104.846	111.116	114.790	105.221	105.181	110.502	118.307	107.478	111.001
62	2M15	Male	Senior	Cat 1-3A	97.435	102.163	106.489	96.435	97.144	96.259	103.192	99.182	103.305
63	2M16	Male	Senior	Cat 1-3A	113.010	110.314	109.074	110.850	114.574	110.091	108.377	111.094	114.097
64	5M1	Male	Senior	Cat 3B	98.621	96.164	94.119	100.784	94.793	96.105	95.339	99.962	98.346
65	5M2	Male	Senior	Cat 3B	100.917	98.615	97.164	107.461	100.142	104.223	103.343	106.084	100.386
66	5M3	Male	Senior	Cat 3B	98.658	94.979	93.198	94.429	96.635	91.938	89.604	94.682	98.183
67	5M4	Male	Senior	Cat 3B	103.153	98.650	96.959	106.393	104.234	104.279	100.839	105.185	101.377
68	5M6	Male	Senior	Cat 3B	108.940	100.859	95.070	112.192	107.333	106.813	99.164	109.184	104.943
69	5M7	Male	Senior	Cat 3B	92.230	92.931	95.266	89.542	90.238	87.807	91.602	92.578	95.111
70	5M8	Male	Senior	Cat 3B	89.052	91.536	95.233	92.589	87.771	92.474	97.186	95.426	92.839
71	5M9	Male	Senior	Cat 3B	88.585	92.806	97.981	92.631	90.465	95.340	101.947	95.053	93.369
72	5M10	Male	Senior	Cat 3B	90.396	92.019	95.138	89.527	90.306	89.929	93.880	91.546	94.525
73	7M2	Male	Senior	Cat IV	92.093	87.307	87.065	91.591	92.335	90.610	86.854	91.514	90.244
74	7M3	Male	Senior	Cat IV	91.886	88.102	86.670	97.566	90.447	93.192	89.752	95.767	89.253
75	7M4	Male	Senior	Cat IV	101.531	91.732	86.341	106.022	100.850	100.529	90.565	101.771	94.493
76	7M5	Male	Senior	Cat IV	86.419	86.009	87.954	92.161	88.171	89.472	89.980	93.243	88.332
77	7M6	Male	Senior	Cat IV	85.146	85.504	88.439	93.504	85.418	93.017	94.797	94.165	86.385
78	7M7	Male	Senior	Cat IV	84.375	87.285	91.308	90.616	85.342	92.982	98.404	91.040	86.344
79	7M8	Male	Senior	Cat IV	96.974	91.522	89.129	106.347	97.438	102.732	97.429	103.567	92.413
80	3M2	Male	Non-Grad	Cat 1-3A	106.699	105.915	108.200	114.520	113.986	115.517	111.693	115.586	107.534
81	3M3	Male	Non-Grad	Cat 1-3A	114.765	112.145	110.014	121.116	118.246	120.233	114.670	120.290	114.321
82	3M4	Male	Non-Grad	Cat 1-3A	101.745	104.270	106.947	103.575	104.064	104.176	105.583	106.063	105.553
83	3M5	Male	Non-Grad	Cat 1-3A	101.387	102.225	104.912	98.555	105.434	99.917	99.821	101.408	105.492
84	3M6	Male	Non-Grad	Cat 1-3A	111.028	109.542	109.687	112.705	116.236	112.393	109.344	113.474	112.103
85	3M7	Male	Non-Grad	Cat 1-3A	115.247	110.572	107.164	115.472	117.669	113.765	107.037	114.373	113.853
86	3M8	Male	Non-Grad	Cat 1-3A	120.734	122.264	121.196	121.132	122.514	122.170	123.058	121.068	122.790
87	3M9	Male	Non-Grad	Cat 1-3A	96.262	101.627	108.549	97.839	101.810	101.850	106.584	102.685	102.566
88	6M1	Male	Non-Grad	Cat 3B	103.061	98.260	96.884	111.895	106.453	109.204	102.878	110.934	101.193
89	6M2	Male	Non-Grad	Cat 3B	99.612	95.372	93.781	100.255	101.510	98.342	92.816	99.847	98.781
90	6M3	Male	Non-Grad	Cat 3B	89.838	91.764	95.118	94.917	91.493	94.349	96.978	97.249	93.900
91	6M4	Male	Non-Grad	Cat 3B	90.244	90.637	94.798	92.679	94.970	93.744	93.744	95.607	92.929
92	7M2	Male	Non-Grad	Cat IV	92.093	87.307	87.065	91.591	92.335	90.610	86.854	91.514	90.244
93	7M3	Male	Non-Grad	Cat IV	91.886	88.102	86.670	97.566	90.447	93.192	89.752	95.767	89.253
94	7M4	Male	Non-Grad	Cat IV	101.531	91.732	86.341	106.022	100.850	100.529	90.565	101.771	94.493
95	7M5	Male	Non-Grad	Cat IV	86.419	86.009	87.954	92.161	88.171	89.472	89.980	93.243	88.332
96	7M6	Male	Non-Grad	Cat IV	85.146	85.504	88.439	93.504	85.418	93.017	94.797	94.165	86.385
97	7M7	Male	Non-Grad	Cat IV	84.375	87.285	91.308	90.616	85.342	92.982	98.404	91.040	86.344
98	7M8	Male	Non-Grad	Cat IV	96.974	91.522	89.129	106.347	97.438	102.732	97.429	103.567	92.413
99	1F1	Female	HSDG	Cat 1-3A	90.436	96.763	106.482	89.242	91.015	94.636	104.326	96.394	98.388
100	1F2	Female	HSDG	Cat 1-3A	105.543	112.359	115.934	97.909	100.613	99.503	109.189	101.838	110.401

APPENDIX C.3

Supply Group AA Means

CCLUSTER	CL_ID	SSEX	EDSTAT	AFQT2	GM	EL	CL	MM	SC	CO	FA	OF	ST
101	1F3	Female	HSDG	Cat 1-3A	101.488	103.837	108.374	105.802	106.017	108.702	110.433	109.827	107.112
102	1F4	Female	HSDG	Cat 1-3A	109.826	116.714	121.809	107.484	112.604	113.720	122.268	112.604	119.041
103	1F5	Female	HSDG	Cat 1-3A	100.222	102.317	105.553	95.123	101.071	97.336	100.541	99.252	106.339
104	1F6	Female	HSDG	Cat 1-3A	116.410	122.437	125.004	113.653	116.498	120.569	127.691	116.616	123.113
105	1F8	Female	HSDG	Cat 1-3A	113.567	116.909	118.550	109.118	114.679	111.734	116.280	111.867	119.904
106	1F9	Female	HSDG	Cat 1-3A	97.151	101.528	107.642	93.071	98.102	93.588	100.985	99.356	105.236
107	1F10	Female	HSDG	Cat 1-3A	96.839	101.253	106.175	96.080	95.456	97.942	103.788	100.327	102.274
108	1F11	Female	HSDG	Cat 1-3A	94.575	102.322	111.729	93.597	97.923	101.210	111.490	100.375	103.864
109	1F12	Female	HSDG	Cat 1-3A	100.103	108.333	116.019	98.289	101.252	107.944	118.474	103.763	108.921
110	1F13	Female	HSDG	Cat 1-3A	90.551	96.165	105.526	85.548	92.580	90.222	97.878	92.547	98.104
111	4F1	Female	HSDG	Cat 3B	91.963	92.037	93.919	94.840	90.680	92.974	93.914	97.141	94.772
112	4F2	Female	HSDG	Cat 3B	92.860	93.967	96.234	97.643	94.060	97.673	99.799	100.492	97.449
113	4F3	Female	HSDG	Cat 3B	90.983	91.259	94.243	87.440	91.549	89.427	91.048	90.885	95.228
114	4F4	Female	HSDG	Cat 3B	86.241	90.537	97.138	87.800	86.518	89.447	97.434	92.490	91.911
115	4F5	Female	HSDG	Cat 3B	87.274	90.041	95.335	84.297	86.336	83.721	90.000	89.015	92.608
116	4F6	Female	HSDG	Cat 3B	86.606	90.268	95.750	91.002	86.416	95.478	101.122	94.609	91.549
117	4F7	Female	HSDG	Cat 3B	84.271	89.229	97.048	87.218	84.592	91.974	100.548	91.677	90.044
118	4F8	Female	HSDG	Cat 3B	84.794	87.654	94.022	86.236	84.914	86.154	91.173	91.374	90.107
119	7F1	Female	HSDG	Cat IV	83.343	85.357	90.829	88.929	83.414	89.586	94.743	92.071	86.786
120	7F2	Female	HSDG	Cat IV	87.523	86.554	87.338	90.892	87.000	86.938	87.723	92.538	90.569
121	7F3	Female	HSDG	Cat IV	84.857	85.659	88.407	92.033	83.890	91.637	93.857	93.132	86.571
122	2F1	Female	Senior	Cat 1-3A	96.572	101.958	107.584	92.500	93.123	92.814	102.213	98.047	102.969
123	2F2	Female	Senior	Cat 1-3A	103.646	107.129	109.911	97.719	103.739	100.738	107.288	101.317	111.913
124	2F3	Female	Senior	Cat 1-3A	109.685	116.014	119.289	106.332	110.110	109.205	118.216	110.453	118.518
125	2F4	Female	Senior	Cat 1-3A	108.475	115.746	119.497	106.074	108.537	111.755	121.150	109.653	117.160
126	2F6	Female	Senior	Cat 1-3A	93.488	98.411	106.107	85.539	93.788	89.184	97.927	92.400	101.836
127	2F7	Female	Senior	Cat 1-3A	93.331	100.343	108.611	93.065	94.129	100.464	110.541	98.972	102.205
128	2F8	Female	Senior	Cat 1-3A	94.356	101.951	110.914	93.191	97.554	100.191	110.912	100.119	104.714
129	2F9	Female	Senior	Cat 1-3A	98.811	102.488	106.159	95.268	95.974	95.212	101.812	99.108	104.729
130	5F2	Female	Senior	Cat 3B	93.772	95.553	97.285	98.556	94.054	98.057	103.182	100.485	100.694
131	5F3	Female	Senior	Cat 3B	91.864	92.975	94.777	86.752	89.652	87.276	91.292	89.950	97.125
132	5F4	Female	Senior	Cat 3B	90.942	92.985	94.978	93.865	88.526	91.465	95.545	95.695	94.815
133	5F5	Female	Senior	Cat 3B	88.506	91.234	96.364	85.467	87.953	86.553	93.426	90.234	94.763
134	5F6	Female	Senior	Cat 3B	87.831	91.251	96.786	90.534	86.024	95.228	102.021	94.402	92.638
135	5F7	Female	Senior	Cat 3B	86.748	91.779	98.197	88.474	85.860	91.785	100.570	92.342	91.651
136	5F8	Female	Senior	Cat 3B	87.078	89.942	95.244	86.236	83.824	85.178	92.770	91.178	92.964
137	7F1	Female	Senior	Cat IV	83.343	85.357	90.829	88.929	83.414	89.586	94.743	92.071	86.786
138	7F2	Female	Senior	Cat IV	87.523	86.554	87.338	90.892	87.000	86.938	87.723	92.538	90.569
139	7F3	Female	Senior	Cat IV	84.857	85.659	88.407	92.033	83.890	91.637	93.857	93.132	86.571
140	3F1	Female	Non-Grad	Cat 1-3A	95.767	101.995	108.432	97.398	98.597	102.655	108.316	101.990	102.403
141	3F2	Female	Non-Grad	Cat 1-3A	98.051	100.258	104.566	95.167	102.030	97.682	99.348	99.727	104.667
142	3F3	Female	Non-Grad	Cat 1-3A	98.611	101.150	106.580	103.031	105.062	105.927	106.005	107.850	103.591
143	3F4	Female	Non-Grad	Cat 1-3A	110.630	115.901	119.307	111.010	114.807	115.885	120.469	114.297	117.458
144	3F5	Female	Non-Grad	Cat 1-3A	93.035	99.589	108.052	90.935	96.186	95.485	103.251	97.857	101.190
145	6F1	Female	Non-Grad	Cat 3B	86.229	90.857	97.800	92.029	90.914	97.486	102.800	97.400	94.371
146	6F2	Female	Non-Grad	Cat 3B	87.925	88.700	93.975	88.650	90.375	88.900	90.300	93.750	92.375
147	6F3	Female	Non-Grad	Cat 3B	94.235	93.294	94.294	96.794	94.088	94.206	93.853	98.353	96.559
148	7F1	Female	Non-Grad	Cat IV	83.343	85.357	90.829	88.929	83.414	89.586	94.743	92.071	86.786
149	7F2	Female	Non-Grad	Cat IV	87.523	86.554	87.338	90.892	87.000	86.938	87.723	92.538	90.569
150	7F3	Female	Non-Grad	Cat IV	84.857	85.659	88.407	92.033	83.890	91.637	93.857	93.132	86.571

APPENDIX C.4

Supply Group Descriptions
Based on Aptitude Area Scores and Average AFQT Scores

SUP		EDUC	AFQT	---------AVERAGE AA SCORES---------									OK DEP	AVG AFQT
GRP	GNDR	LVL	CAT.	GM	EL	CL	MM	SC	CO	FA	OF	ST	DELAY	SCORE
1	MALE	HSDG	I-IIIA	95	100	107	92	94	93	100	97	101	08	59
2	MALE	HSDG	I-IIIA	114	117	118	113	116	114	118	115	118	08	76
3	MALE	HSDG	I-IIIA	111	108	107	115	112	113	110	115	111	08	62
4	MALE	HSDG	I-IIIA	120	117	115	125	122	125	120	124	118	08	73
5	MALE	HSDG	I-IIIA	126	127	126	126	126	128	129	126	127	08	89
6	MALE	HSDG	I-IIIA	112	116	116	105	111	108	114	106	118	08	74
7	MALE	HSDG	I-IIIA	104	106	108	107	107	108	111	111	113	08	62
8	MALE	HSDG	I-IIIA	96	103	112	98	100	107	115	103	103	08	63
9	MALE	HSDG	I-IIIA	123	118	112	121	122	119	113	119	120	08	70
10	MALE	HSDG	I-IIIA	97	102	108	89	98	93	100	94	103	08	59
11	MALE	HSDG	I-IIIA	128	126	123	124	127	123	122	122	127	08	85
12	MALE	HSDG	I-IIIA	100	103	107	102	101	103	106	105	103	08	59
13	MALE	HSDG	I-IIIA	110	106	104	110	114	110	104	110	110	08	58
14	MALE	HSDG	I-IIIA	111	117	120	107	108	111	119	109	116	08	79
15	MALE	HSDG	I-IIIA	101	107	111	104	104	104	111	104	106	08	62
16	MALE	HSDG	I-IIIA	114	112	110	112	109	107	106	112	111	08	65
17	MALE	HSDG	I-IIIA	119	124	123	118	119	118	124	118	125	08	85
18	MALE	HSDG	I-IIIA	111	111	115	117	116	121	121	117	112	08	69
19	MALE	HSDG	I-IIIA	97	104	111	97	101	101	110	102	105	08	62
20	MALE	HSDG	I-IIIA	103	102	107	106	108	107	105	109	103	08	58
21	MALE	HSDG	I-IIIA	115	111	110	121	120	120	113	120	113	08	64
22	MALE	HSDG	I-IIIA	122	126	126	121	122	127	132	122	127	08	90
23	MALE	HSDG	I-IIIA	101	102	104	96	101	96	98	99	104	08	57
24	MALE	HSDG	I-IIIA	132	131	127	131	130	132	132	129	131	08	92
25	MALE	HSDG	I-IIIA	112	119	123	110	114	116	125	114	120	08	83
26	MALE	HSDG	I-IIIA	112	109	108	108	112	105	103	109	112	08	62
27	MALE	HSS	I-IIIA	112	114	115	111	113	112	115	113	116	08	70
28	MALE	HSS	I-IIIA	113	118	118	108	111	108	116	108	120	08	75
29	MALE	HSS	I-IIIA	109	109	109	105	104	103	105	108	109	08	61
30	MALE	HSS	I-IIIA	111	109	110	117	114	117	115	117	112	08	62
31	MALE	HSS	I-IIIA	116	121	123	115	117	119	126	117	123	08	83
32	MALE	HSS	I-IIIA	106	106	106	99	104	99	101	100	108	08	58
33	MALE	HSS	I-IIIA	122	125	123	122	121	123	127	121	125	08	84
34	MALE	HSS	I-IIIA	94	101	109	92	95	98	107	98	101	08	60
35	MALE	HSS	I-IIIA	120	115	110	118	117	114	110	116	118	08	65
36	MALE	HSS	I-IIIA	99	103	108	92	99	95	102	97	105	08	59
37	MALE	HSS	I-IIIA	126	125	122	124	125	123	123	122	126	08	83
38	MALE	HSS	I-IIIA	110	110	108	111	108	108	109	111	113	08	61
39	MALE	HSS	I-IIIA	101	107	113	103	106	108	116	107	110	08	65
40	MALE	HSS	I-IIIA	105	111	115	105	105	111	118	107	111	08	69
41	MALE	HSS	I-IIIA	97	102	106	96	97	96	103	99	103	08	57
42	MALE	HSS	I-IIIA	113	110	109	111	115	110	108	111	114	08	62
43	MALE	NHS	I-IIIA	107	106	108	115	114	116	112	116	108	08	61
44	MALE	NHS	I-IIIA	115	112	110	121	118	120	115	120	114	08	68
45	MALE	NHS	I-IIIA	102	104	107	104	104	104	106	106	106	08	61
46	MALE	NHS	I-IIIA	101	102	105	99	105	100	100	101	105	08	58
47	MALE	NHS	I-IIIA	111	110	110	113	116	112	109	113	112	08	64
48	MALE	NHS	I-IIIA	115	111	107	115	118	114	107	114	114	08	63
49	MALE	NHS	I-IIIA	121	122	121	121	123	122	123	121	123	08	84
50	MALE	NHS	I-IIIA	96	102	109	98	102	102	107	103	103	08	61
51	MALE	HSDG	IIIB	88	93	98	89	89	90	98	91	92	08	38
52	MALE	HSDG	IIIB	97	98	96	99	96	96	99	98	101	08	40
53	MALE	HSDG	IIIB	96	92	94	101	97	98	93	102	93	08	38
54	MALE	HSDG	IIIB	105	100	96	116	108	112	104	113	101	08	41
55	MALE	HSDG	IIIB	97	93	92	92	96	90	87	93	96	08	38
56	MALE	HSDG	IIIB	99	95	93	103	97	98	95	102	97	08	40

APPENDIX C.4

Supply Group Descriptions
Based on Aptitude Area Scores and Average AFQT Scores

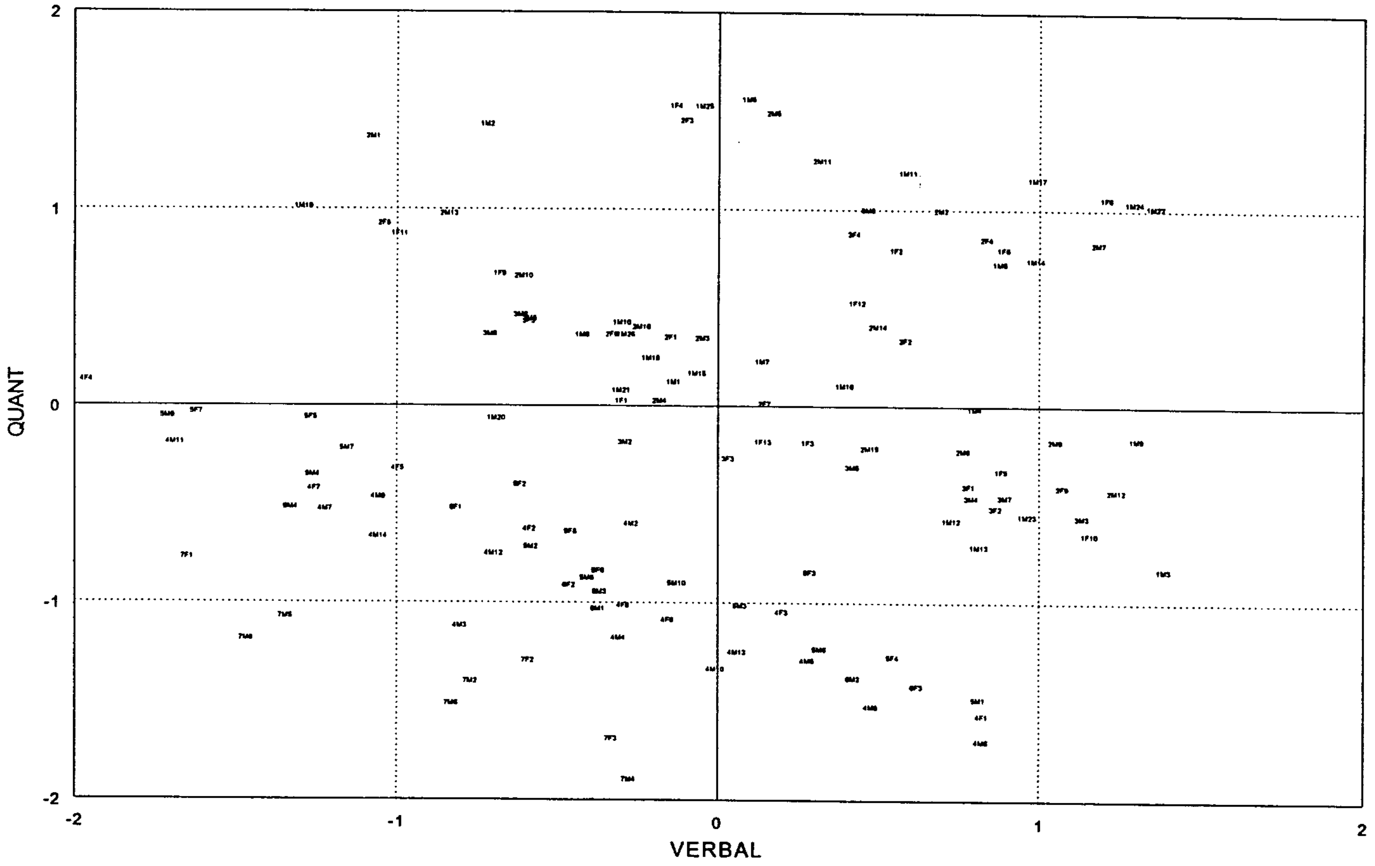
SUP		EDUC	AFQT	---------AVERAGE AA SCORES---------									OK DEP	AVG AFQT
GRP	GNDR	LVL	CAT	GM	EL	CL	MM	SC	CO	FA	OF	ST	DELAY	SCORE
57	MALE	HSDG	IIIB	86	89	96	89	86	90	96	92	90	08	38
58	MALE	HSDG	IIIB	107	99	94	111	108	106	96	108	103	08	40
59	MALE	HSDG	IIIB	89	90	95	87	91	88	91	90	93	08	38
60	MALE	HSDG	IIIB	88	90	94	93	88	92	95	96	91	08	38
61	MALE	HSDG	IIIB	94	96	98	102	98	103	105	102	97	08	40
62	MALE	HSDG	IIIB	93	95	98	101	94	103	107	100	95	08	40
63	MALE	HSDG	IIIB	88	89	93	87	89	88	90	90	91	08	38
64	MALE	HSDG	IIIB	103	97	95	108	106	104	98	106	100	08	40
65	MALE	HSS	IIIB	99	96	94	101	95	96	95	100	98	08	40
66	MALE	HSS	IIIB	101	99	97	107	100	104	103	106	100	08	41
67	MALE	HSS	IIIB	99	95	93	94	97	92	90	95	98	08	38
68	MALE	HSS	IIIB	103	99	97	106	104	104	101	105	101	08	40
69	MALE	HSS	IIIB	109	101	95	112	107	107	99	109	105	08	41
70	MALE	HSS	IIIB	92	93	95	90	90	88	92	93	95	08	38
71	MALE	HSS	IIIB	89	92	95	93	88	92	97	95	93	08	39
72	MALE	HSS	IIIB	89	93	98	93	90	95	102	95	93	08	39
73	MALE	HSS	IIIB	90	92	95	90	90	90	94	92	95	08	39
74	MALE	NHS	IIIB	103	98	97	112	106	109	103	111	101	08	41
75	MALE	NHS	IIIB	100	95	94	100	102	98	93	100	99	08	39
76	MALE	NHS	IIIB	90	92	95	95	91	94	97	97	94	08	39
77	MALE	NHS	IIIB	90	91	95	93	95	94	94	96	93	08	38
78	MALE	HSDG	IV	92	87	87	92	92	91	87	92	90	08	28
79	MALE	HSDG	IV	92	88	87	98	90	93	90	96	89	08	28
80	MALE	HSDG	IV	102	92	86	106	101	101	91	102	94	08	28
81	MALE	HSDG	IV	86	86	88	92	88	89	90	93	88	08	28
82	MALE	HSDG	IV	85	86	88	94	85	93	95	94	86	08	28
83	MALE	HSDG	IV	84	87	91	91	85	93	98	91	86	08	28
84	MALE	HSDG	IV	97	92	89	106	97	103	97	104	92	08	28
85	MALE	HSS	IV	92	87	87	92	92	91	87	92	90	08	29
86	MALE	HSS	IV	92	88	87	98	90	93	90	96	89	08	26
87	MALE	HSS	IV	102	92	86	106	101	101	91	102	94	08	28
88	MALE	HSS	IV	86	86	88	92	88	89	90	93	88	08	27
89	MALE	HSS	IV	85	86	88	94	85	93	95	94	86	08	27
90	MALE	HSS	IV	84	87	91	91	85	93	98	91	86	08	29
91	MALE	HSS	IV	97	92	89	106	97	103	97	104	92	08	26
92	MALE	NHS	IV	92	87	87	92	92	91	87	92	90	08	29
93	MALE	NHS	IV	92	88	87	98	90	93	90	96	89	08	28
94	MALE	NHS	IV	102	92	86	106	101	101	91	102	94	08	28
95	MALE	NHS	IV	86	86	88	92	88	89	90	93	88	08	28
96	MALE	NHS	IV	85	86	88	94	85	93	95	94	86	08	28
97	MALE	NHS	IV	84	87	91	91	85	93	98	91	86	08	27
98	MALE	NHS	IV	97	92	89	106	97	103	97	104	92	08	29
99	FEML	HSDG	I-III	90	97	106	89	91	95	104	96	98	08	57
100	FEML	HSDG	I-III	106	112	116	98	101	100	109	102	110	08	74
101	FEML	HSDG	I-III	101	104	108	106	106	109	110	110	107	08	62
102	FEML	HSDG	I-III	110	117	122	107	113	114	122	113	119	08	82
103	FEML	HSDG	I-III	100	102	106	95	101	97	101	99	106	08	60
104	FEML	HSDG	I-III	116	122	125	114	116	121	128	117	123	08	88
105	FEML	HSDG	I-III	114	117	119	109	115	112	116	112	120	08	79
106	FEML	HSDG	I-III	97	102	108	93	98	94	101	99	105	08	61
107	FEML	HSDG	I-III	97	101	106	96	95	98	104	100	102	08	60
108	FEML	HSDG	I-III	95	102	112	94	98	101	111	100	104	08	64
109	FEML	HSDG	I-III	100	108	116	98	101	108	118	104	109	08	73
110	FEML	HSDG	I-III	91	96	106	86	93	90	98	93	98	08	57
111	FEML	HSS	I-III	97	102	108	93	93	93	102	98	103	08	59
112	FEML	HSS	I-III	104	107	110	98	104	101	107	101	112	08	64

APPENDIX C.4

Supply Group Descriptions
Based on Aptitude Area Scores and Average AFQT Scores

SUP		EDUC	AFQT	---------AVERAGE AA SCORES---------									OK DEP	AVG AFQT
GRP	GNDR	LVL	CAT	GM	EL	CL	MM	SC	CO	FA	OF	ST	DELAY	SCORE
113	FEML	HSS	I-III	110	116	119	106	110	109	118	110	119	08	79
114	FEML	HSS	I-III	108	116	119	106	109	112	121	110	117	08	79
115	FEML	HSS	I-III	93	98	106	86	94	89	98	92	102	08	57
116	FEML	HSS	I-III	93	100	109	93	94	100	111	99	102	08	60
117	FEML	HSS	I-III	94	102	111	93	98	100	111	100	105	08	61
118	FEML	HSS	I-III	99	102	106	95	96	95	102	99	105	08	59
119	FEML	NHS	I-III	96	102	108	97	99	103	108	102	102	08	00
120	FEML	NHS	I-III	98	100	105	95	102	98	99	100	105	08	00
121	FEML	NHS	I-III	99	101	107	103	105	106	106	108	104	08	00
122	FEML	NHS	I-III	111	116	119	111	115	116	120	114	117	08	00
123	FEML	NHS	I-III	93	100	108	91	96	95	103	98	101	08	00
124	FEML	HSDG	IIIB	92	92	94	95	91	93	94	97	95	08	41
125	FEML	HSDG	IIIB	93	94	96	98	94	98	100	100	97	08	41
126	FEML	HSDG	IIIB	91	91	94	87	92	89	91	91	95	08	40
127	FEML	HSDG	IIIB	86	91	97	88	87	89	97	92	92	08	40
128	FEML	HSDG	IIIB	87	90	95	84	86	84	90	89	93	08	40
129	FEML	HSDG	IIIB	87	90	96	91	86	95	101	95	92	08	40
130	FEML	HSDG	IIIB	84	89	97	87	85	92	101	92	90	08	39
131	FEML	HSDG	IIIB	85	88	94	86	85	86	91	91	90	08	39
132	FEML	HSS	IIIB	94	96	97	99	94	98	103	100	101	08	41
133	FEML	HSS	IIIB	92	93	95	87	90	87	91	90	97	08	41
134	FEML	HSS	IIIB	91	93	95	94	89	91	96	96	95	08	41
135	FEML	HSS	IIIB	89	91	96	85	88	87	93	90	95	08	40
136	FEML	HSS	IIIB	88	91	97	91	86	95	102	94	93	08	40
137	FEML	HSS	IIIB	87	92	98	88	86	92	101	92	92	08	40
138	FEML	HSS	IIIB	87	90	95	86	84	85	93	91	93	08	40
139	FEML	NHS	IIIB	86	91	98	92	91	97	103	97	94	08	00
140	FEML	NHS	IIIB	88	89	94	89	90	89	90	94	92	08	00
141	FEML	NHS	IIIB	94	93	94	97	94	94	94	98	97	08	00
142	FEML	HSDG	IV	83	85	91	89	83	90	95	92	87	08	28
143	FEML	HSDG	IV	88	87	87	91	87	87	88	93	91	08	28
144	FEML	HSDG	IV	85	86	88	92	84	92	94	93	87	08	28
145	FEML	HSS	IV	83	85	91	89	83	90	95	92	87	08	00
146	FEML	HSS	IV	88	87	87	91	87	87	88	93	91	08	00
147	FEML	HSS	IV	85	86	88	92	84	92	94	93	87	08	00
148	FEML	NHS	IV	83	85	91	89	83	90	95	92	87	08	00
149	FEML	NHS	IV	88	87	87	91	87	87	88	93	91	08	00
150	FEML	NHS	IV	85	86	88	92	84	92	94	93	87	08	00

APPENDIX C.5
Scatter Plot of Supply Groups Centroids



APPENDIX C.6

SAS/IML Program Listing Used in the Computation of Test Statistic

```
/********************************************************************************************/
/* The test stat CHI in this macro is based on test of mean vector and covariance matrix    */
/* discussed on pages 440-442 of                                                            */
/*                                                                                          */
/*   Anderson, T.W., An Introduction to Multivariate Statistical Analysis (2nd ed.),       */
/*   John Wiley and Sons, New York, 1984                                                    */
/*                                                                                          */
/* The exact distribution of the test is chi-square with .5*p*(p+1)+P, where p is the number */
/* of variables which are sampled from a multivariate normal population.                    */
/*                                                                                          */
/* Adjusted .05-level critical values are given in Table 4 of EPAS Task 1 discussion and    */
/* is also reported by the program when the appropriate mission group code is provided.     */
/********************************************************************************************/

%macro monitest(sampdata,pardata,gcode);
proc iml;
  %let analvar=gs ar no cs as mk mc ei ve;
  use &sampdata;
  read all var {&analvar} into x;
  close &sampdata;
  nobs = nrow(x);
  nvar = ncol(x);

  use &pardata;
  read point ((&gcode-1)*(nvar+1)+1) var {&analvar} into meanb;
  read point (((&gcode-1)*(nvar+1)+2):((&gcode-1)*(nvar+1)+10)) var {&analvar} into varb;
  close &pardata;

  cholvar = root(varb);

  chidf=.5*nvar*(nvar+1)+nvar;
  critval=cinv(.95,chidf);

  xmean=x[+,]/nobs;
  b=(x-j(nobs,1)*xmean)`*(x-j(nobs,1)*xmean);
  ivarb=inv(varb);
  bivarb=b*ivarb;
  chi = -2*((.5*nvar*nobs)-log(nobs)*(.5*nvar*nobs) + log(det(bivarb))*(.5*nobs) + (-
.5*(trace(bivarb)+
        nobs*(xmean-meanb)*ivarb*(xmean-meanb)`)));

  title1 "Simultaneous Test of Mean and Variance";
  title2 "Mission Group Code = &gcode";
  print chi[rowname={"Test Stat = "}
           label="" format=8.4];
  quit;
run;
%mend;

/*********************************************************************************************/
/*                        *** ADDITIONAL NOTES AND EXAMPLE USAGE ***                          */
/*                                                                                           */
/*   X.SAMPM1S is a sample of size n=400 Cat1-3A, male, high school senior mission            */
/*   groups with group code=2.                                                               */
/*                                                                                           */
/*   X.PARAMS is the SAS data set of ASVAB test score means and covariances for the 14       */
/*   working mission groups.                                                                 */
/*                                                                                           */
/*   The ASVAB variable names must follow the usual convention as: GS AR NO CS AS MK MC EI VE. */
/*                                                                                           */
/*********************************************************************************************/

%monitest(x.sampmls,x.params,2);
```

APPENDIX D

Applicants, Training Seats, and Accession Requirements: Inputs into the Optimization Model

It is convenient to think of the inputs to the classification optimization in terms of the supply of applicants and the demand for training (or trained soldiers). The supply of applicants is approximated by a forecast of monthly contracts. The forecasts are disaggregated into EPAS supply groups. Demand for training for the fiscal year is summarized by DMPM enlisted accession mission requirements for NPS Trainers (i.e. non-prior-service recruits requiring training). Training requirements are developed as FY MOS level requirements in the Army's MOS Annual Program. These requirements are passed to EPAS by REQUEST. Training requirements are met by applicants contracting for and starting MOS specific training. The scheduling of training classes is done by TRADOC and provided through ATRRS, while the availability of training seats is managed by AMB and USAREC. Training seat data is passed to EPAS by REQUEST.

Supply of Applicants

Purpose. A twelve-month forecast of monthly applicant flow by EPAS supply groups (SG) is a key data requirement in the classification optimization model. Forecasted contracts are employed as a proxy for forecasted applicants. They represent the "supply" side of the model.

Source. USAREC PAE (Mission Division) makes forecasts of monthly net contract production.[45] These forecasts extend 12 months into the future, and are updated on a quarterly basis. Forecasts are made for the three mission categories: GA (high school graduate, TSC 1-3A), SR (high school seniors), OTHER (all others). Only command level totals are needed.

Processing Required. The requisite monthly SG forecasts can be obtained in three steps as described below. Additional data requirements are also described.

In the first step, the monthly net production forecasts by mission category are obtained from USAREC as a file of 36 numbers: 3 categories by 12 months. These net contract forecasts are then inflated by expected DEP losses in order to obtain gross contracts. DEP loss rates have averaged about 20 percent over the year; we use monthly DEP loss rates provided by USAREC PAE.[46]

In the second step, factors are applied so as to disaggregate the three mission categories into thirteen demographic groups as shown in Table 1.

---

[45] Monthly net contract production equal the difference between the number of applicants signing contracts during the month (i.e., gross contracts) and the number of DEP losses occurring that month.

[46] These DEP loss rates should refer to contract month; starting with October, they are: 15.4%, 14.3, 6.5, 22.7, 15.6, 12.7, 13.1, 17.0, 28.7, 36.8, 23.0, 18.1.

Table 1: Disaggregation Factors

Disaggregation factors	Description of the numerator
GMA / GA	1. Graduate, male, 1-3A
GFA / GA	2. Graduate, female, 1-3A
SMA / SR	3. Senior, male, 1-3A
SFA / SR	4. Senior, female, 1-3A
SMB / SR	5. Senior, male, 3B
SFB / SR	6. Senior, female, 3B
GMB / OTHER	7. Graduate, male, 3B
GFB / OTHER	8. Graduate, female, 3B
GM4 & NM4 / OTHER	9. Graduate, male, TSC IV; Non-graduate, male, TSC IV
NMA / OTHER	10. Non-graduate, male, 1-3A
NMB / OTHER	11. Non-graduate, male, 3B
NFA / OTHER	12. Non-graduate, female, 1-3A
NFB / OTHER	13. Non-graduate, female, 3B

These factors should be estimated with regression equations over approximately a 5-year period using monthly observations of group shares. This allows the estimation of seasonal effects and any policy effects believed to influence the composition within the three mission categories. The factors should be updated about once a year. Specification and estimation results of the regression equations in use for the prototype PC-EPAS are described in Appendix D.1.

In the third step, monthly forecasts for each of the 13 groups (delineated above) are prorated among their corresponding supply groups. For example, the GMA forecast for the month is allocated among the 26 GMA supply groups according to each supply group's relative size. As part of prototype PC-EPAS development work, supply group relative sizes have been determined in cluster analyses described in Appendix C. Procedures for monitoring and updating the results of the cluster analyses are described in Appendix C.

Given DEP loss rates, disaggregation factors, and supply group relative sizes, the calculation of monthly forecasts by EPAS supply group is straightforward. For the PC-EPAS prototype this is accomplished in an EXCEL spreadsheet, and illustrated in Appendix D.2.

One additional consideration requires discussion. The EPAS optimization model is a "monthly" model that is updated and run weekly. In moving through the weekly cycle, the current month contains progressively fewer weeks' worth of forecasted contracts --- going from four to three to two to one weeks' worth. At the beginning of the cycle, the model will use the full forecast for the current month; at the start of the second week, the model will use an adjusted forecast for the remaining three weeks of the current month, etc. Procedures for making the adjusted forecast are described in Appendix D.3.[47]

---

[47] The adjustments can be made at the 3 mission category level or at the 13 demographic group level. A simplistic approach is to calculate the adjusted forecast as the difference between the original forecast and the actual contracts up to that point. Various smoothing techniques can also be applied.

Accession and Training Requirements

Purpose. Monthly accession requirements and annual MOS training requirements for the current fiscal year (FY) and for the next FY are key data requirements in the classification optimization model.[48] Next FY's requirements are needed by early April of the current year. Requirements represent the "demand" side in the model.

Source. Monthly total accession and priority MOS requirements are found in the DMPM accession letter, and also with the REQUEST NEWQTA data file.

MOS training requirements are contained in the (active Army) MOS Annual Program file accessed within REQUEST. These data are maintained by NPS male trainers and NPS female trainers; TSC 1-3A targets and 3B and 4 maximums are also presumed available.[49]

Processing Required. Each time the EPAS model is run (i.e., weekly), remaining requirements must be calculated. These are the difference between current requirements (i.e., reflecting changes to the original program) and the sum of shippers and current reservations to date. In REQUEST, DEP losses as they occur decrement current reservations. Losses subsequent to the reception station are beyond REQUEST's scope and need not be tracked.

In the current formulation of the EPAS optimization model, MOS requirements data are combined by MOS cluster. MOS clusters in EPAS are defined by aptitude area (AA) composite and cut score, and reflect gender and/or education restrictions (see Rudnik and Greenston, 1996). For each MOS cluster, NPS trainer requirements variables are calculated as follows: male numbers; females as a percentage of the total; a combined (male & female) 1-3A percentage of the total; and combined TSC IV percentage limit.

In sum, each week EPAS receives updated requirements and shippers / reservations counts from REQUEST. These data are used to calculate remaining requirements for the variables described above.

Detailed Methodology. The calculations of remaining requirements are spelled out in greater detail below.

(1) For the current and remaining months: Unfilled monthly accession requirements for NPS trainers. This is the difference between the existing (original or revised) monthly requirement and the sum of shippers and those in DEP scheduled to ship during the month. See AAMMP(k) in model tables.

For k = t,...12:

---

[48] "Missioned" MOS have specific monthly accession goals as well as a total FY requirement. Prototype testing will determine if additional constraints are needed in the optimization model to meet these goals.

[49] The MOS Annual Program is the sum of the AIT/OSUT requirement, a plus-up for expected DEP attrition which goes to zero 30 days before class start, and a plus-up for expected reception station and BT training attrition. A "cousin" of the program can be found in the Seabrook report (produced by USAREC).

$UAR(k) = AR(k) - [OSUT(k) + BT(k) + DEP(k)]$,

> where k = training start month; UAR = unfilled accession requirements; AR(k) = initial/revised accession requirements; OSUT(t) and BT(t) are current month shippers; DEP are existing reservations.

Note: The AR(k) requirements should be inflated for expected DEP loss, based on historical loss rates for those accessing in month k, given the current month t. *Understanding is confirmed by AMB*. Recommend that we utilize "build-to" missions provided by USAREC (see "FY99 Mission / Build-To By Enlistment Type"). If rates (or inflation factors) are not currently available from REQUEST, arrangements should be made to acquire (directly or indirectly?).

(2) For the current and remaining months in the FY, and for each missioned MOS: Unfilled monthly missioned MOS accession requirements. This is the difference between existing requirements and the sum of shippers and those in DEP scheduled to ship during the month. See MISSION(m,k) in model tables.

For k = t,....12, and m = 1,.....for set of missioned MOS:
$UMISS(m,k) = MISS(m,k) - [OSUT(m,k) + BT(m,k) + DEP(m,k)]$,

> where UMISS = unfilled monthly missioned MOS accession requirements; OSUT(m,k) and BT(m,k) are current month shippers; DEP(m,k) are existing reservations.

Note: The MISS(m,k) requirements should be inflated for expected DEP loss, based on historical loss rates for those accessing in month k (and MOS cluster m), given the current month t. *Confirmed by AMB*. Recommend that we utilize build-to estimates provided by USAREC (see "Mission MOS Training Seat Analysis"). If estimates or rates are not currently available from REQUEST, arrangements should be made to acquire.

(3a) For the current FY, and for each MOS: Unfilled annual training requirements (the annual program). For OSUT MOS, this is the difference between existing requirements and the sum of shippers to date and those scheduled to ship in the current FY. For AIT MOS, this is the difference between existing requirements and the sum of shippers to date and those scheduled to ship before month 11 of the current FY. See FYREQ1(m) in model tables.

For m = 1,.......
$UTR(m) = TR(m) - [\Sigma\ OSUT(m,k) + \Sigma\ BT(m,k) + \Sigma\ DEP(m,k)]$,

> where m = MOS; UTR = unfilled training requirement; TR = initial/revised training requirement; OSUT and AIT are training starts; DEP are existing reservations.

Note: MOS training requirements have been inflated for expected DEP and post-ADA loss *(confirmed by SA)*.

(3b) Same as (3a) for the next fiscal year.

(4a) For the current FY and each MOS: Unfilled TSC 3B & 4 annual training requirement limits. This is the difference between the existing requirement limit and the sum of 3B-4 shippers to date and those 3B-4 scheduled to ship in the current FY. See N3B4L1(m) in model tables.

$$UN3B4(m) = N3B4(m) - [\Sigma\ OSUT\text{-}3B4(m,k) + \Sigma\ BT\text{-}3B4(m,k) + \Sigma\ DEP\text{-}3B4(m,k)]$$

where UN3B4 = unfilled training requirement limits; N3B4 = initial/revised limits; OSUT-3B4 = current month TSC 3B-4 OSUT training starts; AIT-3B4 = current month TSC 3B-4 AIT training starts; DEP-3B4 = existing TSC 3B-4 reservations.

Note: These are the 3B & 4 limits that complement the 1-3A targets. Also, see above note. *(Further investigation required.)*

(4b) Same as (3a) for the next fiscal year.

(5) For the current FY: Unfilled (and allowable) TSC 4 training requirement limits. This is the difference between the existing requirement limit and the sum of TSC 4 shippers to date and those TSC 4 scheduled to ship in the current FY. See NCAT41 in model tables (Appendix E).

$$UNCAT4 = NCAT4 - [\Sigma\ OSUT\text{-}4(k) + \Sigma\ BT\text{-}4(k) + \Sigma\ DEP\text{-}4(k)],$$

where definitions are analogous to above.

Note: The TSC 4 limitation could alternatively be stated as an accession limit.

Training Seats

Purpose. Unfilled training seats scheduled to be made available over the next 24 months are a key data requirement in the classification optimization model. Supply meets demand by the filling of training seats.

Source. ATRRS provides MOS training class schedules and seat quotas by RECSTA date. These are managed by AMB and USAREC, and provided to REQUEST. EPAS utilizes two quota sources: active Army NPS males (WJ) and active Army NPS females (WK). EPAS can receive seat data either from REQUEST or directly from the ATRRS. While the latter source represents "true" availability and is most consistent with the EPAS optimization function, the need for coordination in the management of EPAS argues for use of REQUEST as the source.

Processing Required. The EPAS optimization model utilizes a current snapshot of unfilled training seats, up to 24 months into the future (depending on the final specification). The model requires an update of unfilled seat data each time it is run (weekly). Total seats available is the sum of raw quota, the ATRRS plus-up for training base attrition, and a REQUEST plus-up for DEP attrition.[50]

The model operates with monthly data. This means that the seat quotas must be aggregated by (or "rounded" to) RECSTA training start month. In a following step, the RECSTA month MOS seat data are aggregated by MOS cluster.

Detailed Methodology. For the current and remaining months in the FY, and for the 12 months of the next FY: Unfilled monthly (Active Army) RECSTA training seats by MOS. See CLMAX(m,k) in model tables (Appendix E).

Note : Seat counts are inflated for expected post-ADA (active duty accession) loss by the ATRRS, and for expected DEP loss by REQUEST. *(Confirmed – SA)* In this way actual seats are transformed into training opportunities. EPAS should "see" all unfilled scheduled seats/training opportunities, including those that are being temporarily held back. *(Should not be a problem – under investigation.)*

---

[50] A seat plus-up for expected DEP (also called pre-ADA or active duty accession) loss is added by REQUEST. This plus up is zeroed out of the seat total 30 days prior to the start of the class.

APPENDIX D.1

REGRESSION EQUATIONS TO ESTIMATE DISAGGREGATION FACTORS

Given the USAREC forecast of net production, the task here is one of disaggregation from the three mission categories (GA, SR, OTHER) to the thirteen groups used as building blocks in forming the EPAS supply groups.

The equations used to disaggregate the USAREC mission category forecasts were estimated with grouped Army (gross) monthly contracts data, covering the January 1992 – April 1996 period, and were provided by Defense Manpower Data Center (DMDC). Ordinary least squares regressions were run with a constant, monthly indicator variables (s1=Jan, s2=Feb, ...s11; s12 is the omitted indicator), and three policy dummy variables to reflect restrictions put on writing senior contracts during Jun 92 – Aug 92 (s92), Mar 93 – Jun 93 (s93), and Dec 93 – Apr 94 (s94). Use of dummy variables to capture these restrictions would seem to be most appropriate for the original forecasting (i.e. that done by USAREC), but it turns out they appear to pick up compositional effects of the restriction policies. Future analyses to estimate disaggregation factors should identify and track policy changes that are apt to have compositional effects (within the three mission categories).[51]

Table 1 shows the estimated coefficients for the thirteen groups, along with the adjusted R-squared value.

---

[51] During 1995 and 1996 there were changes in the major mission categories, as well as how missions were assigned and achievement evaluated. Presumably these changes are captured in the analyses behind USAREC's forecasts. To the extent that there are also compositional effects, they should be identified and captured in the estimation of the disaggregation factors.

Table 1: Disaggregation Factor Coefficient Estimates [See c:\usarec\fmodel2\sheet4]

	GMA / GA	SMA / SR	SFA / SR	SMB / SR	SFB / SR
s92	0.0213	0.060246	-0.077775	0.01467	0.002858
s93	0.0179	0.079772	-0.017869	-0.030411	-0.031493
s94	-0.013682	0.09633	-0.029429	-0.10016	-0.025603
constant	0.77462	0.58852	0.13797	0.2356	0.037911
s10	-0.016015	0.070826	-0.017232	-0.044626	-0.0089682
s11	-0.010384	0.050406	0.0060742	-0.047391	-0.0090894
s12	0	0	0	0	0
s1	0.01172	0.044117	0.0059376	-0.048978	-0.0010766
s2	0.0016851	0.051918	0.0055724	-0.057605	0.00011438
s3	-0.0081942	-0.040492	0.010216	0.0040596	0.026216
s4	-0.032546	-0.11647	-0.0095251	0.078456	0.047542
s5	-0.028471	-0.1046	-0.0050798	0.067596	0.042086
s6	-0.020457	0.1501	-0.023102	-0.119	-0.007993
s7	-0.022659	0.19725	0.001167	-0.16957	-0.028846
s8	-0.01111	0.14029	-0.028314	-0.097487	-0.014485
s9	-0.021475	0.10946	-0.023495	-0.069432	-0.016529
Adj. RSQ	0.34	0.2	0.48	0.09	0.09
		GMB / Other	GFB / Other	GM4&NM4 /	
s92		0.022797	0.048423	0.018355	
s93		0.11595	-0.062957	-0.03674	
s94		0.03407	0.051024	-0.010771	
constant		0.48784	0.13989	0.026939	
s10		0.038901	0.015688	0.038403	
s11		0.00042122	-0.0080037	0.028906	
s12		0	0	0	
s1		0.034479	0.029891	-0.01424	
s2		0.077387	0.020705	0.00063144	
s3		0.096578	0.049222	-0.00306	
s4		0.086997	0.032972	0.016363	
s5		0.048221	0.031991	0.10964	
s6		0.077982	0.021042	0.067922	
s7		0.13009	0.0093107	0.033995	
s8		0.09532	-0.030963	0.044072	
s9		0.037878	0.030398	0.03233	
Adj. RSQ		0.16	0.14	0.16	

Table 1 (continued)

	NMA/Other	NMB/Other	NFA/Other	NFB/Other
s92	-0.06937	-0.013905	-0.0047769	-0.0015202
s93	-0.021002	0.011548	-0.0046554	-0.0021417
s94	-0.052416	-0.012754	-0.0084497	-0.00070231
constant	0.2709	0.032441	0.036323	0.0056709
s10	-0.073331	-0.009431	-0.0084315	-0.0017972
s11	-0.0073242	-0.0094366	-0.0028983	-0.0016643
s12	0	0	0	0
s1	-0.077944	0.032102	-0.007771	0.0034871
s2	-0.10203	0.012947	-0.010214	0.0005737
s3	-0.12997	0.00093443	-0.01363	-0.000074
s4	-0.12571	0.00037506	-0.011449	0.000455
s5	-0.16816	-0.0021207	-0.017923	-0.0016546
s6	-0.13449	-0.01228	-0.017905	-0.002261
s7	-0.13792	-0.012164	-0.020411	-0.002902
s8	-0.08391	-0.0061783	-0.014077	-0.0024769
s9	-0.080462	-0.0096932	-0.008364	-0.002086
Adj. RSQ	0.22	-0.11	0.06	-0.02

APPENDIX D.2

WORKSHEET CALCULATIONS: FROM USAREC FORECAST OF NET CONTRACT PRODUCTION TO EPAS SUPPLY GROUP ESTIMATES

The worksheet calculations shown in the tables below show the steps involved in deriving EPAS supply group estimates, starting from USAREC forecasts of net contract production. These tables illustrate the calculations for October 1996 through January 1997.

USAREC forecasts by mission category are shown in the first table. The disaggregation factor coefficients are shown below the forecasts. These are applied to the three mission categories to produce the thirteen group estimates shown in the second table. In the third table, the monthly group estimates are spread into corresponding EPAS supply groups. As can be seen, there are 150 supply group clusters defined by the cluster analyses, and 127 active EPAS supply groups. The cluster analyses give the relative shares within each of the thirteen groups. For example, the GMA forecast for October 1996 is 3589, and the first GMA supply group (i.e. SG 1) accounts for 3.46% of that total or 94 individuals.

WORKSHEET TABLES: INFLATING & DECOMPOSING FORECASTED NET CONTRACT PRODUCTION

c\usarec\Fmodel2(sheet2)					@ 14 Jan 98	Oct-96	Nov-96	Dec-96	Jan-97
						1	2	3	4
TABLE 1									
Forecasted net production									
GA						3036	2165	2581	2380
SR						2124	2092	2103	2072
Other						1736	1222	1310	1997
Estimated DEP loss rates									
GA						0.154	0.143	0.065	0.227
SR						0.154	0.143	0.065	0.227
Other						0.154	0.143	0.065	0.227
Estimated gross contracts									
GA						3589	2526	2760	3079
SR						2511	2441	2249	2680
Other						2052	1426	1401	2583
Disagg factors		s92	s93	s94	constant	s10	s11	s12	s1
GMA / GA		0.0213	0.0179	-0.0137	0.7746	-0.016	-0.0104	0	0.0117
SMA / SR		0.0602	0.0798	0.0963	0.5885	0.0708	0.0504	0	0.0441
SFA / SR		-0.0778	-0.0179	-0.0294	0.138	-0.0172	0.0061	0	0.0059
SMB / SR		0.0147	-0.0304	-0.1002	0.2356	-0.0446	-0.0474	0	-0.049
SFB / SR		0.0029	-0.0315	-0.0256	0.0379	-0.009	-0.0091	0	-0.0011
GMB / Other		0.0228	0.116	0.0341	0.4878	0.0389	0.0004	0	0.0345
GFB / Other		0.0484	-0.063	0.051	0.1399	0.0157	-0.008	0	0.0299
GM4&NM4 /		0.0184	-0.0367	-0.0108	0.0269	0.0384	0.0289	0	-0.0142
NMA/Other		-0.0694	-0.021	-0.0524	0.2709	-0.0733	-0.0073	0	-0.0779
NMB/Other		-0.0139	0.0115	-0.0128	0.0324	-0.0094	-0.0094	0	0.0321
NFA/Other		-0.0048	-0.0047	-0.0084	0.0363	-0.0084	-0.0029	0	-0.0078
NFB/Other		-0.0015	-0.0021	-0.0007	0.0057	-0.0018	-0.0017	0	0.0035
TABLE 2									
						Oct-96	Nov-96	Dec-96	Jan-97
Groups, ests of						1	2	3	4
GMA						2722	1931	2138	2421
GFA						866	596	622	658
SMA						1655	1560	1324	1696
SFA						303	352	310	386
SMB						479	459	530	500
SFB						73	70	85	99
GMB						1081	696	683	1349
GFB						319	188	196	439
G&N						134	80	38	33

NMA						405	376	380	498
NMB						47	33	45	167
NFA						57	48	51	74
NFB						8	6	8	24
subtotal:GA						3589	2526	2760	3079
subtotal:SR						2511	2441	2249	2680
subtotal:Other						2052	1426	1401	2583

TABLE 3

Note: these counts correspond to first clustering on 94-96 test scores and tabulation to create AA score profile

						Oct-96	Nov-96	Dec-96	Jan-97
SG	abbrev	clustyp	N	share		1	2	3	4
1	gma	111	1510	0.0346		94	67	74	84
2	gma	111	1726	0.0395		108	76	85	96
3	gma	111	1671	0.0383		104	74	82	93
4	gma	111	1922	0.0440		120	85	94	107
5	gma	111	2365	0.0542		148	105	116	131
6	gma	111	1586	0.0363		99	70	78	88
7	gma	111	1642	0.0376		102	73	80	91
8	gma	111	1287	0.0295		80	57	63	71
9	gma	111	1519	0.0348		95	67	74	84
10	gma	111	1220	0.0279		76	54	60	68
11	gma	111	1787	0.0409		111	79	88	99
12	gma	111	1490	0.0341		93	66	73	83
13	gma	111	1429	0.0327		89	63	70	79
14	gma	111	1728	0.0396		108	76	85	96
15	gma	111	1430	0.0327		89	63	70	79
16	gma	111	1715	0.0393		107	76	84	95
17	gma	111	2303	0.0527		144	102	113	128
18	gma	111	1841	0.0421		115	81	90	102
19	gma	111	1420	0.0325		89	63	70	79
20	gma	111	1602	0.0367		100	71	79	89
21	gma	111	1916	0.0439		120	85	94	106
22	gma	111	1864	0.0427		116	82	91	103
23	gma	111	1427	0.0327		89	63	70	79
24	gma	111	2162	0.0495		135	96	106	120
25	gma	111	1894	0.0434		118	84	93	105
26	gma	111	1176	0.0269		73	52	58	65
27	sma	121	1062	0.0498		83	78	66	85
28	sma	121	1549	0.0727		120	113	96	123
29	sma	121	1522	0.0714		118	111	95	121
30	sma	121	1618	0.0759		126	118	101	129
31	sma	121	1572	0.0737		122	115	98	125
32	sma	121	1216	0.0570		94	89	76	97
33	sma	121	1412	0.0662		110	103	88	112

34	sma	121	1024	0.0480		80	75	64	81
35	sma	121	1265	0.0593		98	93	79	101
36	sma	121	1140	0.0535		89	83	71	91
37	sma	121	1481	0.0695		115	108	92	118
38	sma	121	1225	0.0574		95	90	76	97
39	sma	121	1400	0.0657		109	102	87	111
40	sma	121	1290	0.0605		100	94	80	103
41	sma	121	1261	0.0591		98	92	78	100
42	sma	121	1270	0.0596		99	93	79	101
43	nma	131	1108	0.1453		59	55	55	72
44	nma	131	761	0.0998		40	38	38	50
45	nma	131	998	0.1308		53	49	50	65
46	nma	131	893	0.1171		47	44	44	58
47	nma	131	860	0.1127		46	42	43	56
48	nma	131	1129	0.1480		60	56	56	74
49	nma	131	1051	0.1378		56	52	52	69
50	nma	131	825	0.1082		44	41	41	54
51	gmb	112	867	0.0394		43	27	27	53
52	gmb	112	1731	0.0788		85	55	54	106
53	gmb	112	1854	0.0844		91	59	58	114
54	gmb	112	1693	0.0770		83	54	53	104
55	gmb	112	1435	0.0653		71	45	45	88
56	gmb	112	1597	0.0727		79	51	50	98
57	gmb	112	2082	0.0947		102	66	65	128
58	gmb	112	1484	0.0675		73	47	46	91
59	gmb	112	1599	0.0728		79	51	50	98
60	gmb	112	1416	0.0644		70	45	44	87
61	gmb	112	1427	0.0649		70	45	44	88
62	gmb	112	1439	0.0655		71	46	45	88
63	gmb	112	1728	0.0786		85	55	54	106
64	gmb	112	1612	0.0733		79	51	50	99
65	smb	122	892	0.0867		42	40	46	43
66	smb	122	1515	0.1473		71	68	78	74
67	smb	122	1078	0.1048		50	48	56	52
68	smb	122	1009	0.0981		47	45	52	49
69	smb	122	984	0.0957		46	44	51	48
70	smb	122	1141	0.1110		53	51	59	56
71	smb	122	1221	0.1187		57	55	63	59
72	smb	122	1187	0.1154		55	53	61	58
73	smb	122	1252	0.1218		58	56	65	61
74	nmb	132	181	0.2338		11	8	11	39
75	nmb	132	196	0.2532		12	8	12	42
76	nmb	132	229	0.2958		14	10	13	49
77	nmb	132	168	0.2170		10	7	10	36
78	gm4	113	492	0.1311		18	10	5	4
79	gm4	113	640	0.1705		23	14	6	6
80	gm4	113	400	0.1066		14	8	4	3

81	gm4	113	635	0.1692		23	13	6	6
82	gm4	113	671	0.1788		24	14	7	6
83	gm4	113	436	0.1162		16	9	4	4
84	gm4	113	478	0.1274		17	10	5	4
85	sm4	123	4						
86	sm4	123	5						
87	sm4	123	3						
88	sm4	123	8						
89	sm4	123	4						
90	sm4	123	2						
91	sm4	123	9						
92	nm4	133	12						
93	nm4	133	12						
94	nm4	133	11						
95	nm4	133	11						
96	nm4	133	11						
97	nm4	133	7						
98	nm4	133	9						
99	gfa	211	1547	0.1083		94	65	67	71
100	gfa	211	1216	0.0851		74	51	53	56
101	gfa	211	1331	0.0932		81	56	58	61
102	gfa	211	1259	0.0882		76	53	55	58
103	gfa	211	935	0.0655		57	39	41	43
104	gfa	211	1388	0.0972		84	58	60	64
105	gfa	211	815	0.0570		49	34	36	38
106	gfa	211	1061	0.0743		64	44	46	49
107	gfa	211	1185	0.0830		72	49	52	55
108	gfa	211	1241	0.0869		75	52	54	57
109	gfa	211	1245	0.0872		76	52	54	57
110	gfa	211	1052	0.0737		64	44	46	48
111	sfa	221	864	0.1526		46	54	47	59
112	sfa	221	587	0.1037		31	36	32	40
113	sfa	221	629	0.1111		34	39	34	43
114	sfa	221	827	0.1461		44	51	45	56
115	sfa	221	560	0.0989		30	35	31	38
116	sfa	221	789	0.1394		42	49	43	54
117	sfa	221	780	0.1378		42	48	43	53
118	sfa	221	623	0.1100		33	39	34	42
119	nfa	231	206	0.2019		12	10	10	15
120	nfa	231	198	0.1941		11	9	10	14
121	nfa	231	193	0.1892		11	9	10	14
122	nfa	231	192	0.1882		11	9	10	14
123	nfa	231	231	0.2264		13	11	12	17
124	gfb	212	724	0.0995		32	19	20	44
125	gfb	212	1025	0.1409		45	27	28	62
126	gfb	212	723	0.0994		32	19	19	44
127	gfb	212	631	0.0867		28	16	17	38

128	gfb	212	788	0.1083		35	20	21	48
129	gfb	212	1015	0.1395		45	26	27	61
130	gfb	212	1148	0.1578		50	30	31	69
131	gfb	212	1218	0.1674		53	31	33	73
132	sfb	222	369	0.1354		10	10	12	13
133	sfb	222	359	0.1317		10	9	11	13
134	sfb	222	325	0.1192		9	8	10	12
135	sfb	222	338	0.1240		9	9	11	12
136	sfb	222	378	0.1387		10	10	12	14
137	sfb	222	456	0.1673		12	12	14	17
138	sfb	222	500	0.1834		13	13	16	18
139	nfb	232	35	0.3211		3	2	3	8
140	nfb	232	40	0.3669		3	2	3	9
141	nfb	232	34	0.3119		2	2	2	7
142	gf4	213	67						
143	gf4	213	62						
144	gf4	213	90						
145	sf4	223	3						
146	sf4	223	2						
147	sf4	223	0						
148	nf4	233	0						
149	nf4	233	1						
150	nf4	233	1						
total			140727			8151	6393	6411	8343

APPENDIX D.3

PROCEDURES FOR ESTIMATING 4, 3, 2, 1 WEEK FORECASTS FOR THE FIRST MONTH PERIOD

Although EPAS is a "monthly" model in structure, it will be run weekly in an operational setting. Thus, a procedure is needed for prorating the forecasted supply for the model's first month period. In other words, at the beginning of the month, the full month forecast can be used. At the beginning of the second week, we need a supply forecast for the remaining 3 weeks, and so forth.

Let a_j = the share of supply in the remaining j weeks; i.e. $a_4 = 1$. Historical data is used to estimate a_3, a_2, and a_1. Let F_4 = the full month forecast. We want to estimate F_3, F_2, and F_1, i.e. forecasts for the remaining 3 weeks, 2 weeks, and 1 week.. The proposed procedure extrapolates the actual supply obtained to the full month, compares it to the original full month forecast, adjusts the latter, and prorates it to the remaining weeks. The adjustment is done using the smoothing parameters w, where $w_3 <= w_2 <= w_1$. Let A_j represent the actual supply obtained in week j.

$F_3 = a_3 * F$, where $F = F_4 + w_3 * (A_1 / (1 - a_3) - F_4)$.

$F_2 = a_2 * F$, where $F = F_4 + w_2 * ((A_1 + A_2) / (1 - a_2) - F_4)$.

$F_1 = a_1 * F$, where $F = F_4 + w_1 * ((A_1 + A_2 + A_3) / (1 - a_1) - F_4)$.

Initial estimates for a_j are $a_3 = .82$, $a_2 = .62$, and $a_1 = .34$. Some experimentation with the smoothing parameter is called for; initially a value of 0.2 seems reasonable.

APPENDIX E
EPAS Model Description

EPAS Purpose

The EPAS optimization model and post-processor must compute optimal guidance for allocating NPS (non-prior service) applicant supply groups to MOS training class-months (or RECSTA months)[52] throughout the recruiting year. The EPAS optimal guidance (EOG) is utilized by REQUEST to provide applicant-specific MOS class recommendations that will yield the best possible predicted performance[53] while meeting Army requirements.

Methodology Overview

Supply Groups (SG)

EPAS requires supply groups of projected contractees. SG profiles are created by clustering historical contractees by their aptitude area (AA) scores within demographic categories defined by gender, education, and AFQT. USAREC's contract production forecasts are mapped to corresponding SG profiles to create EPAS monthly contractee forecasts. EPAS uses 150 SGs (127 active SGs). Specifications for SGs are in Appendix C, Supply Group Computation Methodology.

MOS Clusters

Like SGs, MOS clusters reduce model size. However they are easier to create because no data analysis or statistical clustering is needed. These clusters are created by grouping Active Army MOS that are open to NPS by: AA category, qualifying or "cut" score, gender restriction, education requirement, priority (missioned) status, and type of training (AIT vs. OSUT). Updates to cluster structure are needed when any of the above MOS characteristics change. Specifications for MOS class clusters are in Appendix B, MOS Cluster Methodology.

Optimization Model

The EPAS multi-period[54] optimization is formulated as a large-scale linear programming (LP) problem. It is solved for that allocation of SGs to MOS clusters that produces the largest total predicted performance subject to meeting accession / training management constraints. This weekly process supports subsequent individual classifications because SGs are surrogates for expected applicants. At the MEPS, REQUEST will then have optimal guidance supporting each applicant's SG.

Since many applicants do not accept the first MOS offered, the optimization model finds a succession of near-optimal SG to MOS cluster matches. After the LP reaches optimality, its

---

[52] MOS training class-month denotes training in a specific MOS during a specific month. Receiving station (RECSTA) month refers to the same concept.

[53] Predicted performance is based on applicant aptitude area (AA) composite scores from the Armed Services Vocational Aptitude Battery (ASVAB).

[54] Using monthly time periods.

reduced costs are used to rank-order 50 successive solutions with values less than or equal to the optimal solution. These solutions' SG-to-MOS cluster assignments constitute the basis for the EOG built in the EPAS-REQUEST Interface (ERI).

The EPAS Optimization Model

Objective function, allocation variable and model indices

The VALUE(i,m) variable denotes the contribution to the objective function of flow between SG(i) and MOS cluster(m). It equals the supply group AA composite score for the job family of the MOS cluster to which the SG has been allocated. The BT(i,j,m,k) variable represents flow from an SG contract-month (i,j) to an MOS cluster class-month (m,k). Embedded functions compare the SG's AA composite scores to MOS cluster cut scores to determine allowable connections, and the SG's contract-month to the MOS cluster's RECSTA month to enforce allowable DEP length and class maximum size. The BT variable is set to zero if these are disallowed or exceeded. The LP objective function seeks to maximize total contractee predicted performance, calculated as the sum of the value-by-flow allocation products.

Table 1. EPAS Optimization Indices

Index Variable	Constant	Constant Value	Label
i	I	150	SG
j	J	12	Contract Month
k	K	24	RECSTA Month
m	M	65	AIT and OSUT MOS Clusters

Since the current EPAS prototype only considers the effect of future contractees from the same recruiting year, only 12 contract months are modeled. Contractees are limited to a 12 month DEP, so 24 RECSTA start months are modeled. (This formulation ignores modeling the few August and September "rising" senior contractees who could DEP to September of the following fiscal year for an AIT class beginning two months afterward (and in the next fiscal year).)

Constraint Structure Explanation

Limit Total Allocation to Available Supply. Available supply limits the total BT allocations. As SGs represent forecasted applicants, the model will attempt to use all of available applicant supply.

Fill MOS Cluster Class Seats (CLMAX). The BT flow to each AIT/OSUT MOS cluster class-month is limited by the maximum class size. Here CLMAX is both a class fill upper limit and a fill target. Alternative formulations could target a lower, nominal fill and/or require a minimum class fill.

Meet Monthly Total and Missioned MOS Accessions. Monthly total accessions and missioned MOS accessions must equal or exceed ODCSPER targets.

Do Not Exceed Annual MOS Cluster Training Targets (FYREQ). Total annual contractee flows to each MOS cluster must not exceed requirements in the annual manpower training program.

Limit AFQT IIIB/IV Contractees to MOS (N3B4). MOS distribution of quality (DQ) is enforced by setting an upper bound on the sum of AFQT IIIB and IV SGs flow to MOS clusters. The upper bound is a number derived from each MOS annual percentage target. The user must change numeric targets when annual MOS requirements are changed. This formulation enforces DQ at the end of the FY, but interim DQ must still be enforced by the REQUEST DQ switches. Note that DQ is enforced on applicant flow to each MOS while AFQT IV limits (described below) are enforced to annual applicant flow.

AFQT IV annual limits (NCAT4). AFQT IV limits are enforced by an upper bound on the sum of CAT IV flow to all MOS clusters in the recruiting year. As with AFQT IIIB + IV limits, these upper bounds are numerical values that represent percentages of annual accessions.

Generic (Algebraic) Formulation

The objective function and constraints, described above, are shown in their algebraic formulation on the following page.

Maximize the objective function:

$$\sum_i^I \sum_j^J \sum_k^K \sum_m^M VALUE_{im} BT_{ijkm}$$

Value of flow to all MOS class clusters

Subject to these constraints:

$$\sum_k^K \sum_m^M BT_{ijkm} = SUPPLY_{ij} \quad \forall i, j$$

All available supply must be allocated

$$\sum_i \sum_j BT_{ijkm} \leq CLMAX_{km} \quad \forall k, m$$

Fill MOS class cluster seats

$$\sum_i^I \sum_j^J \sum_m^M BT_{ijkm} = MONREQ_k \quad \forall k$$

Meet monthly total accession requirements

$$\sum_i^I \sum_j^J BT_{ijkm} = MISREQ_{mk} \quad \forall m, k \quad m \subset missioned MOS$$

Meet monthly missioned MOS targets

$$\sum_i^I \sum_j^J \sum_k^K BT_{ijkm} \leq YREQ_m \quad \forall m$$

Meet annual MOS cluster training targets

$$\sum_i^I \sum_j^J \sum_k^K BT_{ijkm} \leq N3B4_m \quad \forall m, i \subset AFQT \quad IIIB - IV$$

Limit AFQT IIIB/IV contractees to MOS limits

$$\sum_i^I \sum_j^J \sum_k^K \sum_m^M BT_{ijkm} \leq NCAT4 \quad i \subset AFQT\ IV$$

AFQT IV annual limits

PC EPAS Prototype Formulation
(December 1998)

The PC-EPAS prototype optimization model has been coded and solved using DASH Associates[55] XPRESS-MP LP solver. The formulation shown below, **EPASSIM.BT1**, is likely to be the (first generation) penultimate formulation. The final formulation will be tested with "live" data and should support some form of the monthly missioned MOS constraint. [Note: an earlier version, EPASSIM.M17, was used to create baseline runs and verify 1997-98 input data. This version can be found in the EPAS Functional Description, Appendix F.]

```
 MODEL EPASSIM.PRI

SET SINGLE
SET EXTSUB
SET PAUSE

LET
 I = 150     ! No. of Supply Groups
 MA = 060    ! No. of AIT Clusters
 MU = 005    ! No. of OSUT Clusters
 T = 2       ! No. of Periods for Basic Training
 NEGAMT = -.5

TABLES
 Y           ! Periods remaining in Planning Year

DISKDATA
 Y    = YEAR.MAT

ASSIGN
 LET K = 10 + Y   ! No. of Accession Periods

IF Y < 3
  LET J = Y + 3
ELSE
  LET J = Y
ENDIF

SY2 = max(Y-T+1,1)  !Month which Starts FY 2 for AIT

TABLES
SUPPLY (I,12)   ! Supply Group by Contract Month
AAMMP (22)      ! Active Army Accession Goals
CLMAX (MA+MU,24) ! Class Seat UB by Cluster and Month
CLMIN (MA+MU,24) ! Class Seat LB by Cluster and Month
MINPCT (12,12)   ! Class Seat % LB by Cluster and Month
VALUE (I,300)    ! Value of Supply Group to Cluster; = 0 if not allowed
DEPLIM (I,12,24) ! Allowable Delays by Sup Grp, Contract Mo. and Training Mo.
HFYREQ1 (MA+MU)  ! 1st Year Annual Program by Cluster
FYREQ2 (MA+MU)   ! 2nd Year Annual Program by Cluster
```

---

[55] XPPRESS-MP User Guide, DASH Associates, Blisworth House, Church Lane, Blisworth, Northants NN7 3BX, UK, 1994.

```
  N3B4L1 (MA+MU)  ! 1st Year 3B + 4 Cap by Cluster
  N3B4L2 (MA+MU)  ! 2nd Year 3B + 4 Cap by Cluster
  NMALE1 (MA+MU)  ! 1st Year Male Cap by Cluster
  NMALE2 (MA+MU)  ! 2nd Year Male Cap by Cluster
  NCAT41          ! 1st Year CAT IV Cap
  NCAT42          ! 2nd Year CAT IV Cap
  iCAT4 (I)       ! Indices of CAT IV Supply Groups
  iFEMS (I)       ! Indices of Female Supply Groups for Scenario E
  iPRIMOS (MA+MU) ! Indices of Priority MOS Clusters
  iQUAL (I)       ! Indices of Cat I-IIIA Supply Groups
  MISSN (MA+MU,12) ! Class Seat LB by Cluster and Month

 DISKDATA
  AAMMP   = AAMMP.MAT
  CLMAX   = CLMAX.MAT
  MINPCT  = MINPCT.MAT
  VALUE   = COST.MAT
  DEPLIM  = DEPLIM.MAT
  HFYREQ1 = FYREQ1.MAT
  FYREQ2  = FYREQ2.MAT
  iCAT4   = ICAT4.MAT
  iFEMS   = IFEMS.MAT
  iPRIMOS = IPRIMOS.MAT
  iQUAL   = IQUAL.MAT
  MISSN   = MISSION.MAT
  N3B4L1  = N3B4L1.MAT
  N3B4L2  = N3B4L2.MAT
  NMALE1  = NMALE1.MAT
  NMALE2  = NMALE2.MAT
  NCAT41  = NCAT41.MAT
  NCAT42  = NCAT42.MAT
  SUPPLY  = SUPPLY.MAT

DISKDATA -o SUPMTHS.MAT = J

ASSIGN
  ITERMTH = 13 - Y

  SFYREQ1(m=MA+1:MA+MU) = SUM(k=1:Y) CLMAX (m,k)
  SFYREQ1(m=1:MA) = SUM(k=1:Y-T) CLMAX (m,k)
  FYREQ1 (m=1:MA+MU) = min(SFYREQ1(m),HFYREQ1(m))

VARIABLES

BT (i=1:I,j=1:J,k=1:K,m=1:MA+MU|k.GE.j.AND.VALUE(i,m).NE.0.AND.&
      DEPLIM(i,j,k).NE.0.AND.CLMAX(m,k).NE.0) -e

CONSTRAINTS

!********************MAXIMIZE OBJECTIVE FUNCTION

OBJMAX: SUM(i=1:I,j=1:J,k=1:K,m=1:MA+MU) VALUE(i,m) * BT(i,j,k,m) $

!********************ALL SUPPLY MUST BE ALLOCATED

SUPGRP(i=1:I,j=1:J): SUM(s=j:K,m=1:MA+MU) BT(i,j,s,m)  = SUPPLY(i,j)
```

```
!********************ALLOCATIONS CANNOT EXCEED AVAILABLE CLASS SEATS

 MAXBT(m=1:MA+MU,k=1:K): SUM(i=1:I,j=1:J) BT(i,j,k,m) < 1.10 * CLMAX(m,k)

!********************ALLOCATIONS CANNOT EXCEED ANNUAL MOS REQUIREMENTS
!********************FIRST AND SECOND YEARS

 IF Y > T
  REQ1AIT(ma=1:MA): SUM(i=1:I,j=1:J,k=1:Y-T) BT(i,j,k,ma) < FYREQ1 (ma)
 ENDIF

 REQ1OSUT(mu=1:MU): SUM(i=1:I,j=1:J,k=1:Y) BT(i,j,k,MA+mu) < FYREQ1(MA+mu)

 REQ2AIT(ma=1:MA): SUM(i=1:I,j=1:J,k=SY2:K) BT(i,j,k,ma) < &
     FYREQ2 (ma)

 REQ2OSUT(mu=1:MU): SUM(i=1:I,j=1:J,k=Y+1:K) BT(i,j,k,MA+mu) < &
     FYREQ2(MA+mu)

!********************ALLOCATIONS MUST MEET MONTHLY ACCESSION GOALS

 MOACC(k=1:Y): SUM(i=1:I,j=1:J,m=1:MA+MU)  BT(i,j,k,m) > AAMMP (k)

!********************ALLOCATIONS MUST MEET MISSIONED MOS GOALS

! MMOS(m=1:MA+MU,k=1:Y): SUM(i=1:I,j=1:J)  BT(i,j,k,m) > MISSN (m,k)

!********************ALLOCATIONS OBEY 3B+4 LIMITS - FIRST YEAR

 IF Y.GT.T
  TB41A(ma=1:MA): SUM(i=1:I,j=1:J,k=1:Y-T|iQUAL(i).NE.1) &
            BT(i,j,k,ma) < 1.05 * N3B4L1 (ma)
 ENDIF

 TB41O(mu=1:MU): SUM(i=1:I,j=1:Y,k=1:Y|iQUAL(i).NE.1) &
            BT(i,j,k,MA+mu) < 1.05 * N3B4L1 (MA+mu)

!********************ALLOCATIONS OBEY CAT IV LIMITS - FIRST YEAR

 IF Y > T
  CAT41: SUM(i=1:I,j=1:J,k=1:Y-T,ma=1:MA|iCAT4(i).NE.0) BT(i,j,k,ma)  + &
      SUM(i=1:I,j=1:J,k=1:Y,mu=1:MU|iCAT4(i).NE.0) BT(i,j,k,MA+mu) &
            < NCAT41
 ELSE
  CAT41: SUM(i=1:I,j=1:J,k=1:Y,mu=1:MU|iCAT4(i).NE.0) BT(i,j,k,MA+mu) &
            < NCAT41
 ENDIF
```

PC-EPAS MODEL DATA TABLES
ADDITIONAL DESCRIPTION

Allocations are defined by BT(i,j,k,m), where i = supply group, j = contract month, k = accession (i.e., RECSTA) month, and m = MOS cluster; also MA = number of AIT clusters = 60, and MU = number of OSUT clusters = 5.

SUPPLY (I,12) = 150 x 12. Supply (i,j) matrix contains forecasted applicants for each supply group (row) by remaining number of contract months (columns).

DEPLIM (I,12,24) = 150 x 12 x 24. DEPLIM (i,j,k) matrix shows allowed (= 1) and disallowed flows (= 0) between combinations of supply group, contract month, and accession month. This reflects the allowable DEP length parameter which is set by the user (e.g. I-IIIA are allowed to DEP out 6 months), and the restriction that the accession month can never precede the contract month (k .GE. j).

DEPLIM (i,j,k) matrix structure is:

(Row 1) (1,1,1) (1,1,2) (1,1,3) .... (1,1,24)
(Row 2) (1,2,1) (1,2,2) (1,2,3) .... (1,2,24)
....
(Row 12) (1,12,1) (1,12,2) (1,12,3)................(1,12,24)
(Row 13) (2,1,1) (2,1,2) (2,1,3)..................(2,1,24)
....
(Row 1800) ....(150,12,24)

VALUE (I,300) = 150 x 300. VALUE (i,m) or "cost" matrix represents the contribution or value to the objective function of (one unit of) flow between supply group i and MOS cluster m. Each MOS cluster is defined by a particular composite area and cut-score. For each MOS cluster (column), the matrix contains the relevant AA composite score of each supply group (row). When AA(i,m) does not meet or exceed the MOS cluster cut-score, the value is set to zero, and this precludes flow between i and m. (Note: the AA value in the matrix is scaled by 1,000.) For example, MOS cluster 2 is a clerical composite cluster, with cut score of 90; supply group 3 has an AA clerical score of 107.328, exceeding the cut score; and we see that Value (3,2) = .107328.

CLMAX (MA+MU,24) = 65 x 24. CLMAX (m,k) matrix shows the available seats for each MOS cluster (row) by RECSTA month (column) over a 24 month horizon.

AAMMP (22). The AAMMP (k) vector shows the monthly total accession goals.

MISSION (65,12). MISSION (m,k) shows the monthly missioned MOS accession goals for each MOS cluster (row) for each remaining month (column) in the current FY.

FYREQ1 (MA+MU) = 65. The FYREQ1 (m) vector shows the annual MOS cluster training requirement targets (i.e. limits).

IQUAL (I) = 150. The IQUAL (i) vector distinguishes between I-IIIA supply groups (= 1) and other groups (= 0).

ICAT4 (I) = 150. The ICAT4 (i) vector distinguishes between TSC IV supply groups (= 1) and other groups (= 0).

N3B4L1 (MA+MU) = 65. The N3B4L1 (m) vector shows the unfilled TSC 3B & 4 annual training requirement limits for each MOS cluster.

NCAT41. NCAT41 is the unfilled TSC 4 training requirement limit for the current FY.

APPENDIX F
EPAS-REQUEST Interface (ERI) Design

After the LP aggregate allocation problem is solved, the ERI computes the EOG and transmits it to REQUEST. The EOG is merged with the REQUEST list when search mode is run for applicants. These operations produce a list of MOS class recommendations for each applicant. This process of incorporating EPAS EOG in each applicant display list is transparent to the career counselors.

ERI Design: Creating an MOS Class-level EOG

Applicants may not accept the MOS class recommendation from the SG's optimal solution. Therefore, each SG must have a sequence of near-optimal MOS classes.
To compute these MOS class lists, the ERI uses the least negative reduced costs (see below) to generate a sequence of next best, next next best, etc., MOS cluster months. Each SG's ordered list of MOS cluster months is then disaggregated to MOS months with MOS class availability verified. This constitutes the EOG that is forwarded to REQUEST. Appendix F.1 describes the EOG data elements.

Computing Reduced Costs. Reduced costs represent the EPAS objective function change that would result from increasing a SG's applicant flow to one MOS cluster class while reducing flow to another.[56] At the EPAS optimal solution, applicants in the current contract period, j=*, have positive flow from their SG to an MOS cluster RECSTA month. RCBT(i,j,k,m) is the reduced cost for BT(i,j,k,m). For each SG(i,*), the BT(i,*,k,m)[57] are ordered by the absolute values of their corresponding RCBT(i,*,k,m). The result, for current contractees, is each SG's MOS cluster-level ordered list in decreasing order of optimality.

Disaggregating MOS Clusters to Individual MOS RECSTA months. To create the EOG ordered lists of MOS RECSTA months, MOS cluster (m) with a RECSTA month k must be disaggregated to individual MOS with their associated RECSTA months. MOS RECSTA months in the same cluster are placed in reverse order of their MOS current percent fill.[58]

---

[56] All variables in the EPAS optimal solution will have a zero reduced costs. Reduced costs for the remaining variables will have a zero or negative value. Exceptions are alternate optima and degenerate solution variables, which have zero value and zero reduced costs.

[57] For every feasible k and l.

[58] Other MOS RECSTA month ordering criteria could place MOS in order of the number or percentage of unfilled class seats.

Appendix F.1

EOG Data Elements

NAME	PURPOSE	ELEMENTS	VALUE RANGE
SUPPLY GROUP DEFINITION FOR SG (n)	Define characteristics of each SG to support classifying applicant.	SG NUMBER (n) AFQT EDUCATION GENDER AA SCORES (9) GM EL CL MM SC CO FA OF ST ASVAB TESTS (10) GS AR WK PC NO CS AS MK MC EI	1 – 150 I-IIIA, IIIB, IV HSDG, HSS, NHSG M,F
EOG FOR SG (n)	Provide each SG's ordered list of near optimal MOS class RECSTA months	SG NUMBER (n) MOS RECSTA MONTH	1-150 11X1-98XL[59] JAN-DEC FY1 JAN-DEC FY2

---

[59] Last sequential MOS open to AA NPS.

APPENDIX G
Estimation of EPAS Benefits

How much performance improvement is possible?

We reviewed model development and results of several research projects in the area of Army classification of applicants. We began with the ARI Project B study (also referred to as Research-EPAS in ARI slide presentations), and considered the research by Nord and Schmitz in the 1980's; that by Zeidner, Johnson, and Statman at George Washington University in the 1990's; that going on at the Air Force Human Resources Laboratory in the 1990's; and that comprising the current PC-EPAS project at ARI (1993 to present). The predicted performance results are summarized in tables where we attempt to present comparable model results in the same row. Nevertheless, due to differences in data samples and methodology described below, the simulation results are most appropriately compared within rather than across studies. Moreover, it is the differences -- the delta's -- between models within studies that tell a similar story about the benefits of optimizing methodologies.

The nine AA aptitude area scores are the metric of performance currently in use by the Army. The AA composites are typically comprised of three or four ASVAB tests, each test unit-weighted. An alternative set of composites has been developed by the ARI Zeidner, Johnson, and Vladimirsky team. These have been shown to have considerably better correlation with predicted performance. Each PP or predicted performance composite is a full-least squares (FLS) weighted sum of all the ASVAB tests. Zeidner, Johnson, and Vladimirsky estimated PP composites for the current set of 9 job families, for a set of 66 job families (based on interim research results), and for a "final" set of 150 job families. The PC-EPAS modeling and testing uses both these PP composites as well as AA composites. Nord and Schmitz worked with both AA composites and approximate-PP composites, based on FLS weights applied to the AA composites rather than to the ASVAB tests themselves.

Research-EPAS studies. Nord and Schmitz (1989) simulated various selection and assignment policies. This review focuses on those concerned with alternative classification methods and performance criteria, and does not deal with the effects of increasing minimum eligibility scores (i.e., cut scores) for assignment to particular MOS. The simulations differ in the operational constraints on selection and classification included in the models. The data base utilized was a random sample of 4377 accessions from 1984 Army enlistments.

The results of five of the Nord and Schmitz simulations are shown in Table 1. The random model (row 1a) results obtain when no performance information is used for job assignment. The current model (row 1b) results are actual assignments (under 1984 MOS standards) used to calculate a baseline set of average performance scores for each of 36 job clusters (which are representative of MOS). The EPAS(AA) model (row 2a) shows the results of sequential assignments made following maximization of the sum of AA scores in a two-phase procedure (similar to PC-EPAS). This simulation also reflects enforcement of a variety of operational constraints. The remaining two allocation policies used "batch" optimization (i.e., not followed by individual sequential assignments): a network assignment algorithm was used to maximize an objective function subject to supply and demand constraints, but did not enforce the other policy constraints used in EPAS. In the OPTAACL model (row 3a), average AA score in assigned jobs is maximized. In the OPTFLS model (row 3b), performance measured with the approximate-PP metric is maximized.

Nord and Schmitz describe the results of the simulated job assignments for both average AA scores and average approximate-PP scores; the latter are measured in standard deviation units, with random selection and classification corresponding to a mean of zero. The source tables can be found in Nord & Schmitz (1989,Tables 3-11 and 3-12, pp.3-30 to 3-34).[60] As can be seen, the simulated current (i.e., REQUEST) results indicated negligible classification effect irrespective of how it is measured. The EPAS(AA) model results showed average gains over current procedures of 2.5 AA points. The OPTAACL model produces larger gains (of 5.5 AA points) because it embodies few recruiting / training management constraints. The simulation results described in the PP column show the same relative differences. In the table we also show the difference between each model and the random assignment result. By examining the difference, we hold constant the selection effects and focus on the classification effects of the models. The OPTFLS model produces large gains of .151 standard deviation units to classification.

Table 1: Nord & Schmitz simulation results

Classification Method	Average AA	Average Approximate-PP	Difference (PP) (classification effect)
1a. Random	106.1	.189	.000
1b. Current	107.5	.197	.008
2a. EPAS(AA)	110.0	.221	.032
3a. OPTAACL	113.0	.236	.047
3b. OPTFLS		.340	.151

Zeidner-Johnson-Vladimirsky studies. We turn now to the simulations carried out by Zeidner, Johnson, and Vladimirsky in their research on improving Army classification methods. In carrying out their most recent analysis, Zeidner, Johnson, and Vladimirsky (2000) utilized a large sample of 260,000 enlisted soldiers with Skill Qualifications Test (SQT) records over the 1987 – 1989 period, and developed regression models and simulation testing to determine the best set of job families for use in classification procedures and to examine the selection and classification effects of alternative measures of predicted performance. These classification optimization models reflect aggregate supply and demand conditions,[61] but stop short of capturing the operational environment as done in PC-EPAS. Accordingly, it can be argued that their results provide an estimate of the operational potential of an enhanced system.

The Zeidner, Johnson, and Vladimirsky classification effect results are summarized by MPP (mean predicted performance) in Table 2.[62] The results shown are unbiased estimates that

---

[60] Interpretation of Table 1 must be done carefully. The results in the AA column comprise a comparable set. The gains from EPAS(AA) and OPTAACL over the current allocation using the PP-metric (as shown in the PP column) are proportionately not as great, since these simulations actually used AA scores in the objective function.

[61] The optimal allocation of individuals to jobs or families was constrained in all simulations to conform proportionately to the actual distribution of enlistees to jobs in 1989.

[62] The selection effects (not shown) have been estimated at .167 (1997b, pp. 59, 72).

come about with the use of a triple cross analysis sample design.[63] The first column refers to the 1997a study, using N=90,000; and the second column refers to the 1997b study, using N=260,000. The baseline simulation (row 3a) reflects the use of the existing operational job families and current Army procedures (unit-weighted ASVAB tests) to form the composites. In the next step (row 3b), the same operational job family framework is used, but performance composites are estimated using FLS regression weights. Finally, the simulation results (row 3c, 3d) are shown for new and more detailed job family structures of 9, 17, 66, and 150. Substantial improvements in predicted performance can be seen from optimization, the use of FLS weights in forming the corresponding composites, and the use of increasingly differentiated job families over the existing operational job families. Indeed, the mean predicted performance (MPP) obtained with 150 new families and FLS weights is more than eight times that obtained with the existing families and unit weights.

Table 2: Zeidner-Johnson-Vladimirsky results

	MPP(a)	MPP(b)
1a. Random	.000	.000
3. Unconstrained optimization		
3a. 9 existing families / unit weights	.047	.023
3b. 9 existing families/FLS weights	.127	.123
3c. 9 / 17 new families/FLS weights	.148	.145
3d. 66 / 150 new families/FLS weights	.189	.195

(a) Johnson, Zeidner, Vladimirsky, 1996, p. 23; (b) Zeidner, Johnson, Vladimirsky, and Weldon, 2000, p. 29.

In related research conducted by Statman (1993) in the early 1990's, both ASVAB tests and Project A predictors were used in the development of performance composites in an examination of the gains to classification. The research database was comprised of individuals in 18 MOS for which extensive data had been collected as part of ARI's Project A. Using a relatively unconstrained optimization (similar to Zeidner, Johnson, and Vladimirsky), she finds that existing Army procedures yield no classification gain (MPP = -.080, relative to zero for random classification), and that FLS ASVAB composites (MPP = .214) together with individual MOS job families yield substantial gains (MPP = .323). Of particular interest is the additional gain that comes from the use of Project A performance predictors (MPP=.458).

<u>Air Force study of differential assignment potential in the ASVAB</u>. At the Air Force Human Resources Laboratory, Alley and Teachout (1995) conducted analyses to demonstrate the potential classification utility of the ASVAB compared to random and current assignment practices. What makes this work novel is the measurement of the predicted performance gains in terms of equivalent experience levels required to obtain them.

A research database was constructed with a sample of (1,250) first-term enlisted personnel in eight AF specialties; the sample was representative of all AF accessions, presumably in the late 1980's, early 1990's period.

---

[63] Sample A is the analysis sample (N=120,000); it is used in formulating the MOS job family clusters, and in estimating the AV (assignment variable) weights for use in the optimization. Sample C is the simulation sample (N=20,000) used in the classification optimization simulation. Sample B is the evaluation sample (N=120,000) and is used in estimating the EV (evaluation variable) weights for use in evaluating the classification produced in the simulation.

> "Individuals were followed from entry into service into their first job assignments… Prior to enlistment, each job incumbent was administered the ASVAB… The job performance of each incumbent was measured by an in-depth work-sample test designed to assess maximum performance potential under ideal conditions… Job experience measures were recorded as months of service between date of entry into service and the time at which the performance tests were administered." (pp. 1-3)

Performance composites were estimated for each of the eight specialties using the FLS regressions of the work-sample tests against the ASVAB tests and the experience measure. Job experience was held constant (at four years) to equate the estimates for people who had spent varying amounts of time in service.

Three different assignment solutions were investigated. First, a baseline was established which set the average performance of incumbents within each specialty to a standard score metric (mean = 50; standard deviation = 10). This reflected the efficacy of the current assignment system. Second, a linear programming algorithm was used to optimize expected performance across all jobs, subject to the constraint that all jobs be staffed with the same number of personnel as under the present system. Third, a random solution was obtained by simulating without regard to aptitude.

Results of the assignment solutions indicate an increase in overall expected performance between the current and optimized solution of 3.43 units or approximately 0.33 of a standard deviation unit. Job experience (held constant in the classification comparisons) was found to play a substantial role: each one-month increment in experience resulted in a 0.23 unit increase in the performance criterion. Thus, the difference of 3.43 units was equivalent to what would have resulted if each job incumbent had an additional 14.91 months of technical experience.

Testing of early PC-EPAS prototype: planning mode results using 1991-93 data. The PC-EPAS prototype model is solved as an aggregate allocation problem, and also can be simulated to make individual assignments. The former has been called its planning mode, and the latter its simulation mode. In its planning mode, the model solves for that allocation of applicant supply to training seats that maximizes predicted performance while satisfying a variety of training management constraints. In the early prototype version, allocations must meet FY MOS training requirements and MOS specific quality targets, and they cannot exceed available supply. Applicant supply is categorized by AFQT, education status, and gender, and within these by mean ASVAB test score profiles. Job training seats are aggregated by clusters of MOS that are similar in the aptitudes and qualifications required of trainees. The planning mode horizon consists of twelve months' worth of supply and 24 months' worth of training requirements and seats. The planning mode performs an aggregate allocation, matching applicant supply groups and MOS clusters of training class start months. Individual level information is not utilized, and the vagaries of individual assignment are not considered.

The 1991 – 93 accession cohorts were used to create the databases for developing and testing the PC-EPAS prototype. Those non-prior service (NPS) individuals who contracted and eventually accessed during FY 1991-93 were used to populate the data set; also excluded were individuals entering into civilian-trained occupations (e.g., band members). By disconnecting the individual from his/her assigned training, we built a supply data set and a job training data set. The supply data set ignores considerations of DEP loss and any differentiation between applicant and contractee, and the job training data set is a subset of the training opportunities that were actually available at the time. By not using the full set of training opportunities, the power of the optimization is circumscribed.

Planning mode runs have been made with EPAS using both AA and PP metrics (Table 3). As summary measures of performance, we calculate the mean AA and/or PP scores over all supply groups as determined by the aggregate allocation. The classification effect is approximated as the difference between a specific model result and the current (i.e. pseudo-REQUEST) model result.

In the early PC-EPAS prototype development work, the supply side was represented with 91 supply groups, and on the demand side we used 57 job clusters belonging to one of nine AA job families, where clusters differed by AA cut score within job families. The AA metric results can be compared with those from Nord & Schmitz EPAS model results (see Table 1). The performance improvement (i.e., the delta AA) made possible by optimized job-person match is essentially the same: the optimization increases average AA by approximately 3 points relative to current procedures. The differences between levels in the two studies are likely due to differences in sample populations: the quality (i.e., 1-3A percentage) of the 1991-93 cohort exceeds that of the 1984 cohort.

Table 3: PC-EPAS Planning Mode

	AA	PP	Difference (PP)
1a. Random			
1b. Current (pseudo-REQUEST)	110.10	.015	.000
2. Constrained optimization			
2a. 9 families/unit weighted composite (57 clusters)	113.24	.074	.059
2b. 9 families/FLS weights (57 clusters)		.118	.103
2c. 66 families/FLS weights (81 clusters)		.210	.195

As part of PC-EPAS prototype development we also completed a preliminary examination of the classification effects of better composites and more occupational differentiation by utilizing the PP composite weights and job family structures developed by Zeidner, Johnson, and Vladimirsky. Current (i.e., pseudo-REQUEST) procedures for assigning jobs produce a baseline PP score of .015 (standard deviation units). When optimization is introduced, average PP increases to .074 (classification effect of .059).[64] Additional gain is realized when PP composites are utilized (still with 9 families): the average PP increases to .118. Additional gain is realized with introduction of a 66 job family structure: the average PP increases to .210 (classification effect of .195). Note that, relative to Zeidner, Johnson, and Vladimirsky study design and results, these are biased estimates.

<u>Testing of revised PC-EPAS prototypes: simulation mode, 1997-98 data</u>. The revised model better resembles current recruiting practice with its focus on the current fiscal year up until late spring or early summer, at which point the planning horizon begins to include next

---

[64] Note that the model in row 2a is maximizing AA score, and so the estimate of .074 is understated relative to the other models by the same reasoning described in footnote on p. 2.

fiscal year's training requirements and class seats. We call the changing horizon a variable length recruiting business window. The revised prototype approximates such a formulation.[65]

The model formulation has been evolving in an effort to reflect USAREC business practices. In the revised formulation, the planning horizon encompasses the first fiscal year. In the BT1 formulation, allocations must meet (or exceed) FY1 monthly total accession missions but cannot exceed annual MOS training targets, and all supply must be allocated. In effect the model focuses on filling FY1 requirements and AIT training requirements for October and November of FY2. MOS level quality requirements take the form of TSC 3B-4 limits; separate MOS level female targets are not included, nor are explicit monthly missioned MOS goals. In the BT12 formulation, allocations must also meet an approximation to missioned MOS goals. Specifically, allocations must meet (or exceed) the monthly sum of missioned MOS goals, and must meet annual training targets for the missioned MOS. In the revised formulations, there continue to be 127 active supply groups and 65 MOS clusters. Connections between supply groups and MOS clusters obey gender, education, and cut-score restrictions.

The testing has been conducted with "independent" supply and demand data for 1997-98. USAREC FY 1997 contract forecasts and 1997 individual recruit characteristics data were used on the supply side, FY 1997-98 training requirements were taken from the Seabrook report produced by USAREC, and 1997-98 training seat data came from the ATRRS.

We now describe in more detail the procedures we followed to develop the database. The three main data element types – applicant supply, MOS training requirements, and training seats – are taken from readily available, different sources and have to be aligned. (In an operational setting, requirements and seats data will come from the system, and it is only applicant forecast data that is external.) USAREC monthly net contract production forecasts are taken as an estimate of applicants expected to sign contracts during the month.[66] The ATRRS seat data have been summarized and provided by RECSTA month. These data refer to the raw seat quota and the plus-up for post ADA attrition. We further inflate to account for expected DEP loss as an approximation to what is actually done by REQUEST managers when ATRRS seat data is received.[67] Non-prior service MOS level requirements are taken from the Seabrook report snapshot as of the end of FY97.[68]

Alignment procedures consisted of the following. First, we reduced annual requirements for those MOS where requirements initially exceeded seats available. We viewed this as a preferable alternative to adding additional seats. As mentioned, in an operational setting requirements and seats are synchronized. Second, we identified applicants who signed contracts

---

[65] The early prototype included several artificial variables necessitated by the inclusion of FY1 and FY2 requirements over a fixed, 24 month horizon. In this prototype, only FY1 requirements are enforced and artificial variables are not used, while the planning horizon is fixed through the end of FY2.

[66] For the operational model, USAREC monthly net contract production forecasts, as we understand them, would be inflated by a DEP loss factor. The DEP loss factors as estimated by USAREC PAE/Mission Division are (starting with October): 15.4%, 14.3, 6.5, 22.7, 15.6, 12.7, 13.1, 17.0, 28.7, 36.8, 23.0, 18.1.

[67] REQUEST endeavors to provide sufficient contract training opportunities so that USAREC can make its monthly accession missions. The monthly build-to factors used by USAREC (and provided by AMB/PERSCOM) which we use to inflate seats are as follows (starting in October): 19.2%, 19.2, 19.2, 17.8, 17.3, 16.0, 16.1, 17.4, 27.1, 28.1, 22.2, 16.8.

[68] We chose to use an end-of-year snapshot so as to reflect the reduction in requirements that occurred over the year. These requirements include some amount of inflation for expected DEP loss.

in FY96 and were scheduled to start training in FY97, and subtracted these from both FY97 requirements and seats available. The alignment procedures generated a planning mode data set with 78,809 requirements for the first fiscal year (known as FY1); of these, 31,369 were filled by applicants contracting in the previous year, leaving an unfilled FY1 requirement of 47,440.

The simulation mode results reflect individual assignments and, relative to the planning mode, provide a more realistic estimate of the classification gains of the optimizing job-person match. In the simulation mode, the LP model is first solved to produce the aggregate allocation for the planning horizon and the corresponding EOG for month one (i.e., the current month) applicants. Using this guidance, the assignment of individual applicants contracting in the current month is simulated. After the simulation, the current month is advanced and the cycle is repeated. In this way a 12-month simulation is run.

For each applicant the simulation procedure calls for the first 25 job assignment choices to be taken directly from the EOG. If selection cannot be made from this set, it is followed by opportunities taken from the larger set of ATRRS seats available for which the applicant qualifies. In setting out the assignment choices, we ignore timing-of-accession preferences that the applicant or the Army may have as expressed by the DOA window; however, in solving the aggregate allocation we do set allowable training delays (i.e. maximum DEP lengths) and these are reflected in the EOG utilized by the simulation. The applicant is simulated to select from the recommended EOG opportunities in three alternate ways: (a) taking the training opportunity at the top of the list; (b) selecting randomly from the top 5 of the list; (c) selecting randomly from the first 25 on the list. Obviously, the "top of the list" procedure represents close adherence to EPAS guidance and, as such, an upper bound to the performance gain that is likely to obtain in an operational environment. Simulations using the EOG are compared to pseudo-REQUEST mode simulations (the BT0 formulation). In the latter, the applicant selects from a list of job assignments, ordered by training class start date (starting from soonest), for which he/she is eligible.

Table 4 depicts the simulation results for BT0, BT1, and BT12 formulations.[69] A total of 79,372 FY 1997 applicants were simulated. The performance improvement obtained for applicants assigned to either FY1 or FY2 training – the BT1 difference between EOG and pseudo-REQUEST mode simulations – was 3.9 AA points for top-of-the-list selection, 3.6 AA points for top 5, and 3.0 AA points for top 25. These results are striking and strengthen the case for optimizing job-person match because the classification management process as modeled here is considerably more realistic than previous research. Departing from the EOG, as illustrated by random selection from top 25, leads to a loss of about one AA point in performance.[70]

In conducting the simulation procedure, the only connection between the aggregate allocation model (i.e., the production mode engine) and the simulated training assignments is the EOG. We are running an unconstrained simulation and attempting to test the effectiveness of the EOG in conveying training management goals / constraints: FY1 training requirement balance, MOS quality goals, monthly accession missions, and missioned MOS goals. In an operational

---

[69] The LP optimization that generates the EOG was set to allow training delays (i.e. DEP lengths) of 6, 4, and 2 months for TSC 1-3A, 3B, and 4, respectively; seniors can DEP out up to 12 months, but not beyond the following summer (except for rising seniors).

[70] Sensitivity of classification gains to the job-choice model is extensively tested and described in Johnson, et. al (1999).

setting, simulation is replaced by actual assignment which is certainly constrained by REQUEST / RUDEP controls. Thus, one could argue that the unconstrained simulation is very stringent (and unrealistic) testing.

We now summarize the results of this testing.[71] In the first place, the EOG does a respectable job of achieving balance in MOS fill rates over the year. As an illustration, the fill rates achieved for priority / critical MOS using the BT1 formulation are shown in Table 5. These rates should be compared to those obtained from the pseudo-REQUEST simulation. It is also interesting to note how average fill rates decline as one moves away from the optimal guidance (i.e., 84% fill under top 5 compared to 76% fill under top 25). The second question concerns the extent to which the MOS cluster quality goals of the aggregate allocation model are realized as MOS quality fill in the simulation results. A partial answer is provided by examining those clusters comprised of only one MOS because it is relatively easy to isolate the effect. Of the 14 single-MOS clusters that necessarily met their quality allocation goals, there were 8 MOS that made their quality targets in the simulation. Comparable analyses covering multi-MOS clusters have not yet been undertaken, and the question remains open because the single-MOS clusters are not representative of the entire set of clusters. The third question concerns the extent to which the monthly accession mission goals of the aggregate allocation model are realized as monthly accessions in the simulation results. Several measures were developed to illuminate the question: net mission fill or the difference between total monthly accession fill and mission over the year; the number of below-mission-months; and the sum of the differences for the below-mission-months. The BT1 formulation compares not unfavorably with the BT0 results: both have 6 below-mission-months and the sum of those differences are within 300, though BT1 registers net mission fill of a 1700 deficit compared to BT0's 2300 overfill. The fourth question concerning missioned MOS goals may be the most problematic. As mentioned, the BT12 formulation only approximates the monthly missioned MOS because a model with the full-blown constraints would not solve and simulate. We suspect that the alignment between available seats, MOS requirements, and applicant supply was not correct in the database as developed, and this testing will be revisited using "live" (integrated) data directly from the REQUEST system. It is quite conceivable, however, that the relative complexity of the BT12 model could prove unneeded in an operational setting. In this view, EPAS and its EOG focus on job-person match maximizing performance, and the merging of the EOG and REQUEST lists means that meeting missioned MOS goals etc. are managed by REQUEST through RUDEP.

Valuation of the predicted performance improvement

Research-EPAS benefit estimation. Nord and Schmitz (pp. 3-37 to 3-53) describe two methods of benefit estimation (valuation). The first is a net present value calculation, based on the psychological utility theory of valuation, which requires an estimate of the dollar value of one standard deviation improvement in performance.[72] They point out that while an estimate of 40% of salary is judged to be a conservative one, it is perceived as subjective and therefore

---

[71] Based on analyses conducted by Peter McWhite as part of Tasks 3 & 4, and included in forthcoming HumRRO contractor report.

[72] This method and accompanying literature is described in chapter 3 of Zeidner and Johnson, "The Utility of Selection for Military and Civilian Jobs", Institute for Defense Analyses, Paper P-2239, July 1989.

Table 4: Revised PC-EPAS Simulation Mode Testing: 1997-98 data, AA metric only

	Average AA score (FY1 & 2)	FY1 Fill Percentage
1a. Random		
1b. BT0 -- Current (approximation to pseudo-REQUEST[73])		
-- top of list	106.9	94
-- random selection from top 5	107.0	96
-- random selection from top 25	107.0	94
2. Constrained optimization		
2a. BT1 --- 9 families/unit weighted composite (65 clusters)		
-- top of list	110.8	87
-- random selection from top 5	110.6	84
-- random selection from top 25	110.0	76
2b. BT12 --- 9 families/unit weighted composite (65 clusters)		
-- top of list	--	
-- random selection from top 5	--	
-- random selection from top 25	109.9	79

Table 5: Priority MOS Fill Rates (%): BT1 Simulation Mode Results By Selection Method

	Top-of-the-List		Top 5		Top 25	
	EOG	REQ	EOG	REQ	EOG	REQ
11X	100	100	85	100	48	98
13B	83	64	79	100	74	100
14R	70	100	80	100	98	100
14T	70	100	100	100	77	81
19K	53	100	100	100	100	100
31F	39	100	68	100	83	98
31R	78	100	69	100	73	93
45E	29	43	33	41	50	60
45T	100	86	96	67	89	100
63E	100	100	78	100	90	100
63H	68	100	93	100	85	100
63T	78	100	61	100	66	100
77F	100	71	100	74	100	74
92G	100	100	88	100	96	100
92R	100	100	100	100	100	100
98XL	NA	NA	NA	NA	NA	NA
All MOS	87	94	84	96	76	94

---

[73] For FY 1997 accessions, the average AA score of actual assignments made by REQUEST is 108.5.

unreliable. Rather than attempting to directly value the performance gains of the new system, the second method focuses on the opportunity cost of retaining the current system. In the present context, the question is: what would be the additional cost of using current assignment procedures to achieve the same level of performance gains obtainable through optimization procedures? Specifically, using current assignment procedures, how many additional 1-3A recruits, in place of 3B recruits, would be required to achieve the same gains obtained through EPAS(AA), OPTAACL, and OPTFLS procedures, and what would it cost?

The heart of the opportunity cost calculation is determination of the number of additional 1-3A recruits required. The 1984 accession cohort baseline (i.e., the assignments made using the current procedures) is ordered from high to low by AFQT score. For individuals at each percentile score, average and cumulative average predicted performance scores for the job assignments actually made are calculated. To meet a predetermined overall average performance target, individuals from the bottom are successively deleted and replaced with 1-3A recruits (assumed to score at the original 1-3A average) until the performance target is reached.

The estimated opportunity costs for the five Nord and Schmitz simulation results (described above) are presented in Table 6. For each model/scenario, the table shows the percentage of 1-3A recruits that would be needed using current assignment procedures to achieve the MPP improvement made possible by EPAS, the number of additional 1-3A recruits, and the estimated cost of recruiting them. The number of 1-3A recruits and the corresponding costs have been offset by a (small) reduction in attrition that is expected to accompany the optimized job-person match.[74] Average 1984 recruiting costs for high-quality recruits are $8371 and for low-quality recruits are $2290; the estimated marginal cost for high-quality recruits is $26,000, and is assumed to increase one percent for each additional one percent high-quality. The 1984 cohort is comprised of 120,281 individuals.

Table 6: Opportunity cost of achieving equivalent performance, Nord & Schmitz, 1984 cohort

	Mean AA score	MPP improvement	Additional 1-3A Required	Required Percent 1-3A	Opportunity Cost ($ millions)
1a. Random	106.1	.000	-972	58	-20.1
1b. Current	107.5	.008	0	59	0
2a. EPAS(AA)	110.0	.032	3,559	63	81.6
3a. OPTAACL	113.0	.047	5,323	64	121.7
3b. OPTFLS		.151	23,403	79	626.1

For the 1984 accession cohort, 1-3A recruits comprise 59 percent. Using current assignment procedures, Nord and Schmitz estimate that the 1-3A share would have to increase to 63 percent to achieve the performance obtainable through the EPAS(AA) model, and to 79 percent for the OPTFLS model. The corresponding opportunity costs are $81M and $626M per year (in 1986 dollars)!

---

[74] See Nord and Schmitz (1989), pp. 3-41 to 3-43; and Greenston, Nelson, and Gee (1997).

PC-EPAS benefit estimation: early prototype, planning mode, 1991-93 data. We now consider the opportunity costs of PC-EPAS performance improvements. The calculations for the 1991-93 cohort planning mode results are shown in Table 7. (The procedure for these calculations is the same as that described above.) The cohort size is approximately 75,000, with 1-3A recruits comprising about 68%. Average recruiting costs are $11,660 for high-quality and $6,223 for low-quality recruits. Marginal costs are estimated at $35,555 for high-quality recruits, and assumed to increase with high-quality share (unit elasticity). For example, at 80% high-quality share, the average cost has increased to $14,935 for high-quality recruits. Unit recruiting costs refer to 1995. Source: U.S. Army Cost and Economic Analysis Center (USACEAC) Army Manpower Cost System.

Table 7: PC-EPAS opportunity costs, planning mode, 1991-93 cohort

	MPP improvement	Additional 1-3A Required	Required Percent 1-3A	Opportunity Cost ($ M)
1a. Random				
1b. Current (approx to REQUEST)	.000	0	67	0
2. Constrained optimization				
2a. 9 families/unit weighted composite (57 clusters)	.059	5,150	79	186
2b. 9 families/FLS weights (57 clusters)	.103	7,851	85	308
2c. 66 families/FLS weights (81 clusters)	.195	18,724	99+	661

The opportunity cost estimates are quite striking and somewhat higher to those comparable analyses reported by Nord and Schmitz using the 1984 accession cohort.[75] In comparing the results for the two studies, the difference seems to be the larger PC-EPAS estimated MPP improvement -- the smaller 1997 cohort size is approximately offset by the higher 1997 recruiting costs.

PC-EPAS benefit estimation: simulation mode, AA metric, 1997-98 data. We now turn to the opportunity cost calculations most appropriate for estimating the benefits of the proposed first generation operational EPAS, which uses the AA metric of performance. (The figures in Tables 6 and 7 reflect both AA and PP metric results, and point toward improvements that would be made following introduction of the first generation EPAS.)

Using the BT1 formulation results, the procedure for the opportunity cost calculations is the same as that described above. Calculations are made for cohort size of 72,000, with 1-3A recruits comprising about 68%. Average recruiting costs are $11,660 for high-quality and $6,223 for low-quality recruits. Marginal costs are estimated at $35,555 for high-quality recruits, and are assumed to increase with high-quality share (unit elasticity). For example, at 80% high-quality share, the average cost has increased to $14,935 for high-quality recruits. Unit recruiting costs refer to 1995 (Source: USACEAC Army Manpower Cost System).

---

[75] If we use performance improvement results for the 1984 accession cohort -- which are comparable in magnitude to the PC-EPAS planning mode results -- and extrapolate the corresponding opportunity costs to recent cohorts (which are about half the size), the estimates would range from $40M to $300M, and this is before any adjustment for the increase in recruiting costs over the last ten years.

Table 8: PC-EPAS benefit estimation: simulation mode, AA metric, 1997-98 data

	AA improvement	Additional 1-3A Required	Required Percent 1-3A	Opportunity Cost ($ million)
1a. Random				
1b. Current (approximation to REQUEST)	.000	0	68	0
2. Constrained optimization				
2a. 9 families/unit weighted composite				
-- top of list	3.9	8,461	84	272
-- random selection from top 5	3.6	7,328	82	233
-- random selection from top 25	3.0	5,129	78	159

The opportunity cost estimates of the 1997 simulation mode results are shown in Table 8. Opportunity costs are calculated for the three procedures of simulating training selection from the ordered list. The costs of achieving the same level of performance improvement from the current system range from $159M to $272M!

Summary

Despite the data sample and methodological differences (described above), the results of the research and development point to the same conclusions: that optimization can produce striking gains to classification, and that the gains can be substantially amplified with use of better measures of the criterion (i.e. predicted performance) and greater differentiation of job families.

Nord and Schmitz (1989) specify and test several optimization models. The scenarios vary by selection standard, use/nonuse of optimization, classification criterion (AA, approximate- PP), allocation method (random, current, optimal), and simulation method. Their testing establishes the gains to optimized classification, points to a potentially large payoff in moving to a full-least squares measure of performance, and raises the issue of how much these gains would be curtailed in a model of greater operational realism. Zeidner, Johnson, and Vladimirsky confirm the gains to optimization, build a strong case for better measures of performance, and demonstrate additional gains with differentiation of job families. The PC-EPAS research represents the most operational realism, and even in its AA metric simulation version appears to dispel concern about curtailment of classification gains with the introduction of greater operational realism.

APPENDIX H:
Toward 2nd Generation EPAS: New Performance Composites and Job Families

The EPAS enhancement to REQUEST will initially utilize the existing aptitude area (AA) composites (as a proxy for predicted performance) as well as the existing nine operational job families. However, there is now a considerable body of evidence indicating that these operational AA composites are grossly inadequate as measures of performance. We now summarize this research and its implications for developing and evaluating personnel classification systems.[76]

Differential Assignment Theory

Classification research has been conducted by ARI since shortly after World War II. Much of the recent research has been done by the Zeidner – Johnson team at George Washington University Department of Administrative Sciences, and has followed from the earlier Project A and Career Force studies. They have been working to formulate and test classification concepts and methods under the rubric of Differential Assignment Theory (DAT) (Zeidner, Johnson, and Scholarios, 1997).

Following Brogden (1959) and Horst (1954), they argue that mean predicted performance (MPP) is the figure of merit most appropriate for comparing the benefits obtainable from the implementation of alternative system designs and operational strategies for selecting and assigning personnel. Brogden (1959) directly linked measurement of classification efficiency to MPP and, thus, to utility. His allocation equation expresses MPP as a function of predictive validity, intercorrelations among FLS estimates of job performance, and the number of job families. The model makes clear that predictive validity is only one term in the equation and, thus, classification efficiency cannot be described adequately by predictive validity alone (Zeidner and Johnson, 1994, p. 379).

Many investigators, nonetheless, prefer to use predictive validity as the measure of classification efficiency, defining classification efficiency in terms of the effect that proposed changes have on the validities of assignment variables for performance in jobs within their associated job families. These investigators are typically quite pessimistic about the value or utility of personnel classification. They appear to be greatly influenced by the degree of unidimensionality in the predictor space and the undeniably dominant contribution that the largest principal-component factor makes to both the predictor validities and intercorrelations. Thus, they assert that the dominance of the first (largest) factor prevents the realization of significant classification effects. Much of this pessimism results directly from the use of predictive validity as the measure of classification efficiency (Johnson, Zeidner, and Leaman, 1992, p. S-2).

The Zeidner – Johnson approach is to design, test, and evaluate a set of classification simulation experiments, using MPP as the figure of merit. Special precautions are taken to ensure that unbiased estimates of MPP are obtained.

---

[76] This section draws (verbatim at times) from Zeidner-Johnson research reports cited below.

Methodology: Triple Cross-Validation Study Model

As a first step, the comprehensive set of performance measures carefully and scientifically developed in Project A were utilized to assess the accuracy of Skill Qualification Test (SQT) scores as indicators of successful job performance. If similar results could be obtained using SQT scores and Project A performance scores, then there would be confidence in the accuracy of these SQT scores. This proposition was tested over a limited set of MOS, and showed the same results linking ASVAB to SQT scores as linking ASVAB to Project A performance scores. This established the equivalency of SQT (measuring job knowledge) and Project A criteria (measuring hands-on) for classification, and the conclusion that SQT provides an appropriate criterion for use in developing and evaluating personnel classification system characteristics.[77] Accordingly, a large SQT database of 260,000 cases obtained over 1987 – 1989 was utilized in their recent research.

Zeidner and Johnson employ a triple cross-validation simulation design that assures unbiased estimates of classification efficiency in terms of MPP. Three independent samples of recruits are required by the design. The distinct roles of these three samples are as follows: (a) the analysis sample is the source of the weights for computing the assignment variables (AVs) and the MOS clusters; (b) the evaluation sample is the source of the weights for computing the evaluation variables (EV's); and (c) the cross (or simulation) sample is the source of the test score sample entities that are optimally assigned to jobs in the simulation process (Johnson, Zeidner, and Vladimirsky, 1996, documentation page).

This research design effectively eliminates inflation of MPP resulting from capitalization on sampling error. The data utilized in the study was corrected for restriction in range, separately by MOS. The restriction in range is attributable to the operational classification and assignment process. However, no correction is made for restriction due to the selection process, since the study uses the Army sample rather than the youth population (Johnson, Zeidner, and Vladimirsky, 1996, p. iii).

Potential classification efficiency is estimated by simulation of a system in which the assignment of recruits to job families is done so as to optimize the sum of all recruits' AVs corresponding to the family to which each recruit is assigned. A linear programming algorithm is used to maximize this total sum of AVs as the objective function. This is accomplished under the constraint of meeting quotas for each assignment target set proportionately to the accession numbers for the MOS included in the analyses (Johnson, Zeidner, and Vladimirsky, 1996, p.4).

Evaluation of classification efficiency is conducted using predicted performance (i.e., the evaluation variable) based on the same set of predictor variables used to compute AVs. This approach follows Brogden's recommendation for the use of predicted performance as a substitute for unobtainable actual performance across the set of families to which optimal assignment is to be applied (Johnson, Zeidner, and Vladimirsky, 1996, p.8).

---

[77] The conclusion requires a generalization from the limited, though representative, set of MOS that were tested to the entire set for which SQT as a predicted performance proxy is applied.

Findings

Recent research results are summarized in the table below, which depicts the estimated MPP for several experimental conditions. In the first place, the largest immediate improvement that can be provided for any personnel classification system is the use as assignment variables of least squares estimates of performance based on all variables in the operational test battery – that is, in the present context, the adoption of FLS composites as replacements for the present type of aptitude area composites. At the same time, data strongly suggest that the present ASVAB tests have sufficient multi-dimensionality and differential validity to permit effective personnel classification. As can be seen in the table below, assignment variables derived from the ASVAB using FLS procedures produce a five-fold MPP increase over the operational AVs.

Second, the optimal number of job families for inclusion in an FLS composite based personnel classification system is as many families as can be coupled with adequately valid assignment variables. The factor limiting the number of job families is the availability of validity data for the constituent jobs in the job families. Whenever it is not feasible to provide separate FLS composites for each job, it is essential that jobs be clustered into job families in a manner that maximizes classification efficiency (Johnson, Zeidner, and Leaman, 1992, p. S-9). With the existing SQT database, 170 MOS could be designated as kernels with adequate validity data to permit the computation of reasonably stable FLS estimates for use as AVs for assignment purposes. The remaining 75 Army MOS, the non-kernel MOS, are attached by judgment to one of the kernels.[78] This provides first tier (defined below) job families that include all Army MOS to which recruits may be initially assigned (Johnson, Zeidner, and Vladimirsky, 1996, p. 12).

Table 1: Zeidner-Johnson-Vladimirsky-Weldon (2000, p.19) simulation results

Condition	MPP[79]
1a. Random	.000
3. Unconstrained optimization	
3a. 9 existing families / unit weights	.023
3b. 9 existing families / FLS weights	.123
3c. 13 new families / FLS weights	.138
3d. 17 new families / FLS weights	.145
3e. 150 new families / FLS weights	.195

Finally, from a longer-term view point, the researchers note that expansion of the dimensions of the classification battery by the inclusion of more predictors with greater heterogeneity can be expected to increase the potential classification efficiency to about the same extent as can be accomplished by the use of more classification-efficient job families in place of the existing a priori job families (Johnson, Zeidner, and Leaman, 1992, p. S-9).

---

[78] While the empirical classification-efficient clustering algorithm showed substantial superiority to judgment based clustering when only 9 families are to be utilized, no superiority was in evidence as the number of job families reached 25. It would appear that for systems with more than a dozen job families, one can rely on clustering by judgment that considers the operational classification family and CMF's membership, and to a lesser extent, other consideration. See Johnson, Zeidner, and Vladimirsky (1996), p. iv.

[79] The set of SQT scores in each of these MOS was standardized to have a mean of zero and a standard deviation of one within a single MOS.

Implications for 2^{nd} Generation EPAS

As part of 2^{nd} generation EPAS a two-tiered classification system is recommended for operational implementation. The first tier is represented by the EPAS optimization model. It would retain as many MOS as have adequate validity data as distinct, single MOS job families. Other MOS would be aggregated to form job families having adequate validity information for computing FLS estimates as assignment variables. EPAS would operate with these assignment variables and a structure composed of approximately 150 job families. It is worth emphasizing that the first tier structure would be invisible to career counselor and applicant. Its sole purpose is to produce the optimal MOS training recommendations (i.e., the EOG) possible. The second tier consists of a smaller number of new aptitude area composites (17 is the current recommendation) that would be used for the determination of minimum cut scores, counseling, and other purposes that are best accomplished using a visible set of composite test scores (Johnson, Zeidner, and Vladimirsky, 1996, p. i).

These classification research results provide the building blocks for 2^{nd} generation EPAS. Zeidner, Johnson, and team members have derived a classification-efficient 150 first-tier job family structure, and have estimated corresponding FLS predicted performance composites based on ASVAB tests. They have also verified the gender – racial fairness of the proposed new composites (Zeidner, Johnson, and Vladimirsky, 1998). The major outstanding task is describing and discussing the proposed changes with affected offices within the Army, including school proponents and the DMPM, and making them stakeholders of the new system. As part of that process, ARI would conduct testing to examine the demographic effects on MOS composition. This would consist of PC-EPAS prototype simulations and field-testing of the proposed operational system. ARI would also work with the proponents to review the proposed 17 (second-tier) aptitude area and job family structure, and to determine equivalent cut-score for the new aptitude areas.