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SIMULATION UTILITY MANAGEMENT SYSTEM (SUMS): USER'S MANUAL

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This research project produced a multijob/force-level analysis model with supporting software. Incorporated in the Simulation Utility Management System (SUMS) are the abilities to: (a) determine optimal force structures given endstrength, continuation rates, and an applicant pool; (b) allocate personnel within a dynamic multijob system; (c) assess the interdependencies among utility estimates in the multijob system; (d) investigate tradeoffs between single job and overall force-level utilities; and (e) perform sensitivity analyses of the effects of changes in enlistment standards and other personnel policies on single and total system utilities. SUMS provides the user with the capability to affect personnel programs such as: enlistment standards, job classification standards, promotion policies, and force-downsizing policies. These policies can be evaluated in terms of single and total system costs, values, and productive capacities.

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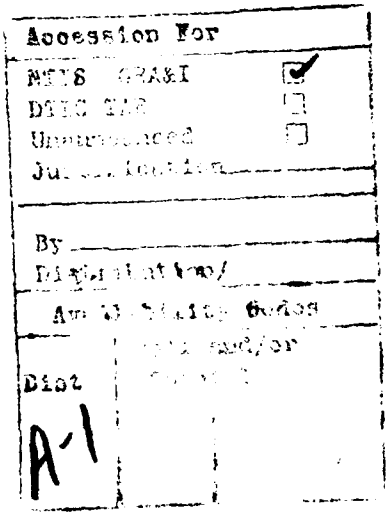

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PREFACE

This research and development effort was conducted as task order number 62 under Contract F41689-88-D-0251 (SBA 68822004) by Metrica, Inc. for the Manpower and Personnel Research Division of the Armstrong Laboratory Human Resources Directorate. The purpose of this effort was to develop a multiple Air Force Specialty (AFS) force analysis model and supporting software package.

The authors wish to thank Dr. Guy Curry, Dr. Brian Deuermeyer, and Mrs. LeAnn Coleman for their valuable technical contributions to this effort. In addition, the authors would like to express appreciation to Ms. Barbara Randall (computer programmer), Mr. Kevin Borden (computer programmer), and Mr. Darryl Hand (computer programmer).

SIMULATION UTILITY MANAGEMENT SYSTEM (SUMS): USER'S MANUAL

SUMMARY

The Simulation Utility Management System (SUMS) and supporting software was developed to provide United States Air Force (USAF) policy makers a tool to assist in the determination of optimal force structures and in the evaluation of the effects of personnel programs on multi-job/force-level systems. This manual guides the user through the SUMS software package with input and output examples and explanations of options and parameters available within SUMS.

SUMS provides the user with the ability to determine optimal force structures by optimizing one of eight possible objectives: including total value, expected total value, total cost, expected total cost, expected total net return, total productive capacity, expected total productive capacity, and a random arrival of applicants. Given continuation rates, an applicant pool and a future endstrength, SUMS provides the user with an optimal force structure. The optimal force structure is determined from the steady-state flow of accessions into the Air Force over a specified horizon. The resulting force structure is defined by AFS, aptitude and year of service (YOS).

Incorporated into SUMS is a enlisted personnel simulation model which begins with an initial inventory of personnel categorized by job, aptitude, grade, and experience. SUMS then ages, separates, promotes, and accesses personnel. The user may specify the job(s) by choosing specific Air Force Specialties (AFSs) or one of two alternative force-level clusterings of AFSs. The user may specify one of three alternative promotion methodologies, as well as the minimum years of service (YOS) requirements for promotion from one grade to the next. Policies such as high year of tenure, minimum promotion selection rates, and accession requirements may also be specified in the simulation.

SUMS provides the user with the ability to study personnel programs such as: enlistment standards, job classification standards, and force-downsizing policies. Enlistment standards for entering accession may be analyzed by specifying minimum General score and overall composite scores (**M**echanical + **A**dministrative + **G**eneral + **E**lectronic). The user may study job classification standards by specifying the selector aptitude index (AI) and the minimum selector AI score for any job in the simulation. Force-downsizing policies may be simulated through the specification of manning levels for jobs.

SUMS provides the user with a variety of output with which alternative programs and policies can be evaluated. The output also provides the user with a year-by-year summary for each job of manning levels, personnel inventories, promotions, separation, force-outs, accessions, and average productive capacity.

INTRODUCTION

The Simulation Utility Management System (SUMS) user interface provides a DOS Windows environment for performing various personnel and management policy analyses and updating and/or modifying the data/parameters supporting the simulation scenarios of SUMS. SUMS was developed to use computer simulation modeling (CSM) in conjunction with utility analysis to analyze the flow of Air Force enlisted personnel. In addition, cost and productive value estimates developed in the Value of Air Force Experience (VAFE) research (Stone, Rettenmaier, Saving, & Looper, 1989; and Stone, Grossman, Looper, & Engquist, 1991) provided the basis to assess dollar-valued utility payoffs for alternative human resource management (HRM) programs (Stone, Turner, Fast, Curry, Looper, & Engquist, 1992a). The user of SUMS is assumed to have some knowledge of Air Force programs used to access, train, promote, reenlist, and separate enlisted personnel.

Given an initial force structure and applicant pool, SUMS can simulate the implementation of a policy decision and then evaluate overall force productive capacity based on that decision. Policies affecting the entire enlisted force or only a few AFSs or a specific grade can be assessed in both the short and long-run using SUMS. Potential tradeoffs between a smaller, more senior force structure compared to a larger, more junior force structure can be investigated using SUMS. Sensitivity analyses of the effects of changes in enlistment standards and other policies on the productive capacity of a single AFS or the entire force may be performed using SUMS.

SUMS also has the capability to assist in the determination of optimal force structures given a future end strength, applicant pool and continuation rates. Alternative aptitude and experience mixes within and across AFSs can be evaluated. The optimal force structure is the steady-state flow of accessions into the Air Force.

To provide flexibility for a wide range of personnel policy and program review, SUMS includes the ability for force-level analysis. SUMS includes Air Force Specialties (AFSs) at the 5-digit level, as well as multiple AFS groupings, referred to as clusters, for force-level analysis capability. Presently, SUMS provides the option to use two different clusterings of AFSs (see Appendix C). SUMS also includes analysis at the grade level (grades E1 through E9).

SUMS provides several options for promotion methodologies. These include promote-to-fill within AFSs/Clusters, Equal Selection Opportunity (ESO) and two-tier promotion. Several methods of allocating accessions are also included in SUMS.

Getting Started

SUMS is designed to operate on a 80486-based PC with a numerical co-processor and 64K cache. A minimum of 16 MB of RAM memory and a minimum of 10 MB of disk space is required to house the data supporting SUMS' operation. The user interface

for SUMS has been implemented under the MS DOS 5.0 operating system and Windows (Version 3.0). A mouse is necessary for movement within the SUMS user interface.

The user may execute SUMS form the DOS command line by typing "WIN SUMS" or from within Windows, the user must select the SUMS icon from the group window. A SUMS icon is provided in the SUMS.EXE file. Installation instructions for adding a program item to a group can be found in your Windows User Manual. The **SUMS Main Menu Screen**, Figure 1, will then appear. This menu will allow the user to choose from the following pull-down menus:

- **Scenario** Specify AFSs/Clusters to be included in the simulation and set the parameters which are not AFS/Cluster specific.
- **Options** Specify promotion and accession allocation methodologies and change costs and values.
- **AFS** Specify AFS/Cluster specific parameters.
- **File** Specify the name of the output file.
- **Execute** Execute a simulation or optimization.
- **Update** Access the automated update capability.
- **Exit** Exit or restart SUMS.
- **Report** View or print selected output, and
- **Help** Help for SUMS and Windows.

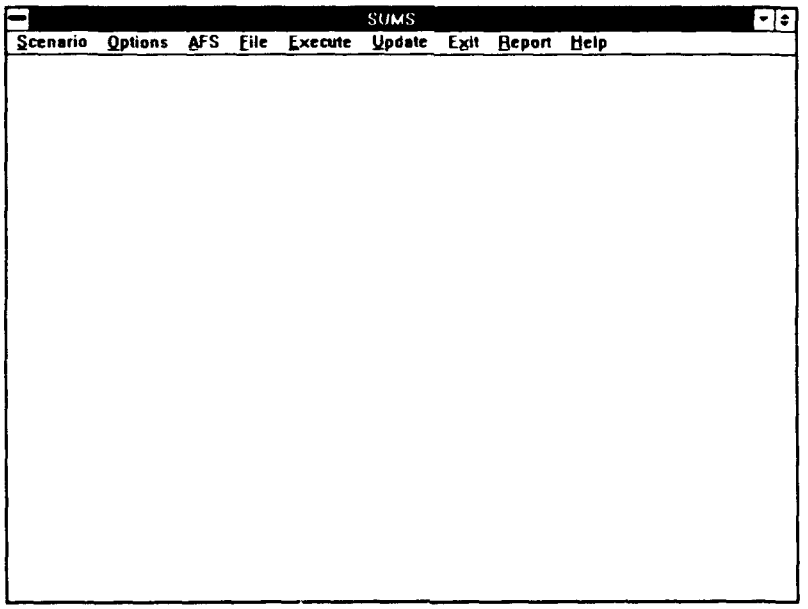

Figure 1. SUMS Main Menu Screen

User Screens in SUMS

Screens in the SUMS user interface will present the user with several options. The user may alter the parameter by using the mouse or keyboard to select the parameter screen and the keyboard to enter new parameter values, or using the mouse to select various parameter options offered in the screen. Each parameter screen will also contain five additional options:

- **OK**,
- **Cancel**,
- **Next**,
- **Previous**, and
- **Help**.

The **OK** option will keep any changes made by the user to the parameter. The user will then be returned to the **SUMS Main Menu Screen**. For example, the user in Figure 2 selected the **Scenario Menu** and then the parameter **Projection Period** and entered a new value at the **Projection Period Screen**. Selecting the **OK** option at the **Projection Period Screen** would return the user to the **SUMS Main Menu Screen** (Figure 1). The revised parameter specified by the user would then be used in the simulation. If the user had not made any changes to the parameters in the **Projection Period Screen**, selecting the **OK** option would also have returned the user to the **SUMS Main Menu Screen**, maintaining the default settings in the simulation for that parameter.

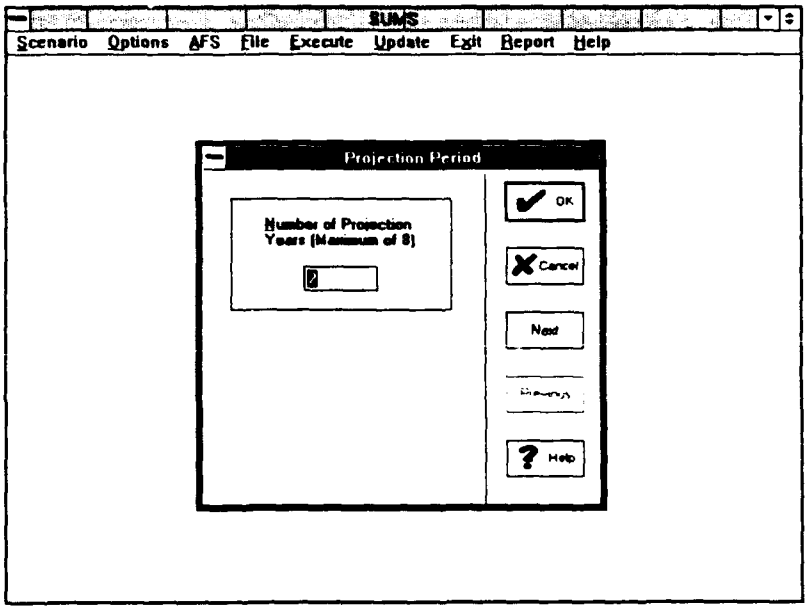

Figure 2. Example: Projection Period Screen

The **Cancel** option will return the user to the original menu, the **SUMS Main Menu Screen**, as the **OK** option above does, but will not keep any changes the user has made to the parameter. Selecting the **Cancel** option will reset the parameter to the default settings or the previous value specified by the user for that parameter.

The **Next** and **Previous** options allow the user to move from screen to screen under a menu without having to return to the main menu. Selecting the **Next** or **Previous** option is the same as selecting the **OK** option discussed above with the exception that the user is not returned to the main menu. For example, if at the **Projection Period Screen** the user selects **Next**, the next screen to appear will be the **Applicant Pool Screen.** Selecting the **Previous** option at the **Applicant Pool Screen** would return the user to the **Projection Period Screen**.

The **Help** option will give the user to access the on-line help feature of SUMS. **Help** will provide the user with a description of the option on the being used and how to change the value of the parameter. **Help** will also provide the source of default values used for each parameter.

To enter new values at parameter screens, the user selects the box corresponding to the value to be changed. For example, if the user had selected the **Projection Period Screen** shown in Figure 2, to change the number of projection periods the user would first click on the projection period box using the mouse. Next, the user would use the Delete or Backspace key on the keyboard to delete the value already in the box. Once the previous value was completely deleted, the user may then enter the new value using the number keys on the keyboard. The user would then select either the **OK**, **Cancel**, **Next** or **Previous** option.

Some parameter and option screens will contain more than one value that the user may edit. For example, the **Costs/Values** screens under the **Options Menu** in the **Scenario Menu** (Figure 3). Costs and value in SUMS may be changed by projection year or across years. If the user had selected **Service State** as the parameter to edit, and chosen to use the **By Years** option, the screen shown in Figure 4 would appear. To change a percent for a particular year, the user would select that year using the mouse. The corresponding value for that year will then appear in the small box. The user may then select that small box, erase the contents of that box, and enter the new percentage change. This process would be repeated as many time as necessary. After all changes have been made, the user would use the **OK**, **Cancel**, **Next** or **Previous** option to exit that screen.

The parameter **Service State** could vary only by/across years. Other parameters or options may vary by AFS/Cluster only, or by AFS/Cluster and by/across years. Some parameters could possibly vary by grade also. The procedure for editing these parameters or options will be similar to that outlined for **Service State**. The user will select the AFS/Cluster for the value to be edited. Then at the small edit box, the user may enter the new values. If the parameter varies by AFS/Cluster and by year, values for the parameter

for the AFS/Cluster selected will appear in small edit boxes for each projection year. The user may edit values for any or all of the years of the projection period.

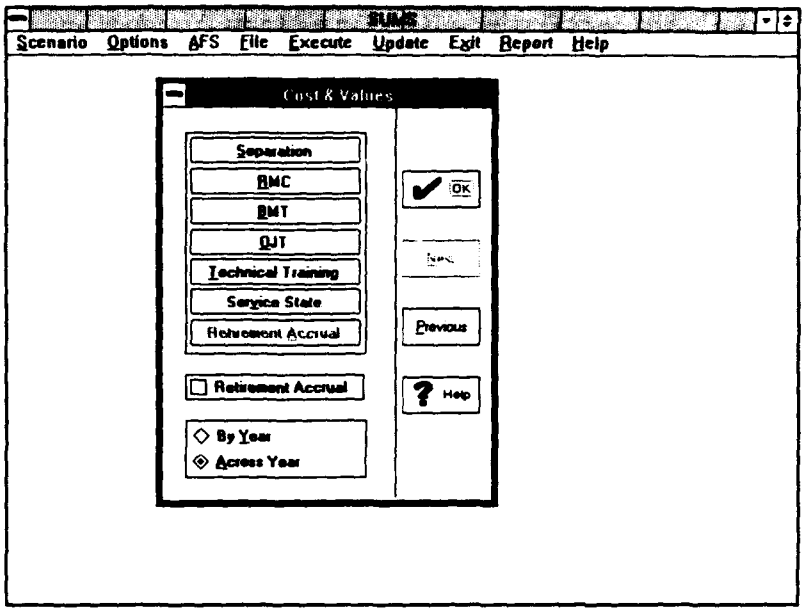

Figure 3. Example: Costs/Values Screen

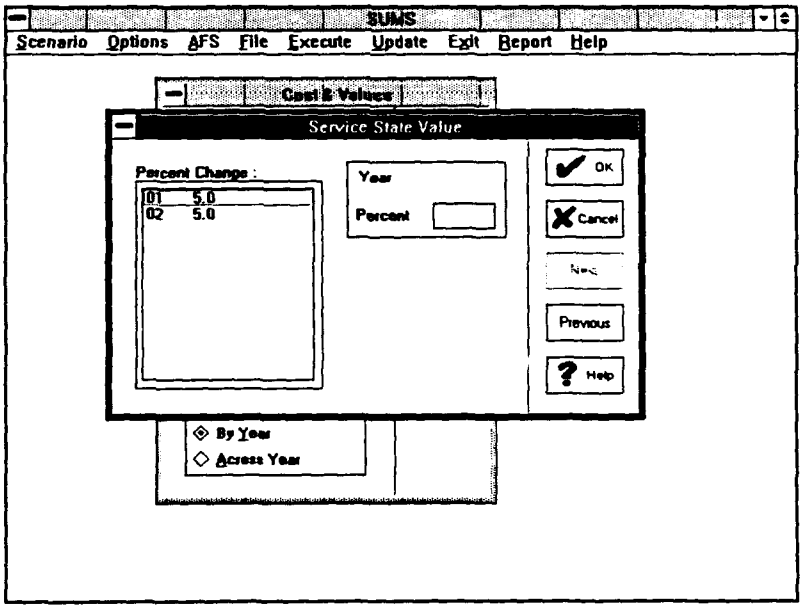

Figure 4. Example: Service State Value -- By Year

SIMULATION AND OPTIMIZATION MODELS IN SUMS

SUMS contains both a simulation model and an optimization model. Inputs for both models differ. All parameters in SUMS are potential inputs for the simulation model. However only a limited number of the parameters available in SUMS may be specified for use in the optimization model. The differences between the two models are discussed below.

Simulation Model

SUMS contains a personnel flow simulation model which imposes continuation rates upon an existing inventory of personnel by grade and aptitude. The allocation module of SUMS allocates accessions to AFSs by aptitude in order to maximize or minimize a user specified objective such as minimization of training and maintenance costs over the career of the recruit. A detailed explanation of the methodology used within the allocation module is included in Appendix A. The existing inventory and the accession allocation which occurs does not necessarily minimize the costs associated with the total force. The existing inventory is a given in any SUMS scenario, and the force structure which results from a simulation in SUMS may or may not provide the maximization or minimization of the stated objective which is used in the allocation module.

The simulation model in SUMS allows the user to specify many personnel policies and programs. Any of the parameters available in SUMS may be used within the simulation. For example, methodologies used for promoting personnel may be specified, as well as policies such as high year of tenure, minimum promotion selection rates, and minimum years of service (YOS) required for promotion. Changes to authorized manning levels may be specified within the simulation, as well as the minimum number of accessions required for each projection year of the simulation. Aptitude requirements for entering accessions may also be specified. All the parameters which may be used to affect the simulation model are discussed in detail in the following sections.

Optimization Model

SUMS also contains an optimization model. The user may specify the stated objective to maximize or minimize, such as minimization of career training and maintenance costs, and the optimization model determines the steady state flow of accessions and force structure (in terms of experience, YOS) which will attain the stated objective. The optimal force structure is dependent on the continuation rates and the aptitude mix by AFS of the steady state flow of accessions. The specified horizon for determining the steady state flow is assumed to be 30 years. A detailed explanation of the methodology used within the optimization model is included in Appendix B.

Only a few of the parameters available in SUMS may be used to affect the optimization model. All parameters affecting the optimization model are discussed in the following sections. The parameter inputs from SUMS for the optimization model include:

- AFSs/Clusters for the population
- Objective function to maximize (minimize)
- Manning levels by AFS/Cluster
- Size and quality mix of the applicant pool
- Continuation rates

The user must specify the AFSs/Clusters to be included in the population (or force) for the optimization. Also the objective function to maximize (minimize) must be specified. The objective function is specified using the accession allocation methodologies from the **Accession Screen** under the **Options Menu**. Any of the eight methodologies may be specified with the exception of Random Arrival. Changes to default manning levels may be specified by AFS/Cluster. Changes to manning levels may not be specified by years or grades for the optimization model.

The size and quality mix of the applicant pool may be specified under the **Scenario Menu** in the same manner as specifying the applicant pool for a simulation. Applicant pool sizes may be specified or the Airman Applicant Prediction System (AAPS) may be used to determine the size and mix of the pool. Continuation rates are also specified in the same manner as for a simulation. Default rates may be used or the Reenlistment/Loss Model may be employed.

DEFINING THE POPULATION

Before the user may execute SUMS, or access any of its parameters or options, the population for the run must first be defined. In defining the population, the user is specifying the AFSs or Clusters which SUMS will use in the simulation or optimization. Clusters are groupings of AFSs which allow the user to perform force-level analysis. Until a population has been defined for SUMS, the user will not be permitted to access any of the pull-down menus other than (Figure 5):

- **Scenario**,
- **Update**,
- **Exit**, and
- **Help**.

The **Scenario Menu** will allow the user to specify the population for SUMS. The user may also update SUMS using the **Update Menu** or exit SUMS by selecting the **Exit Menu** at this time. Help for SUMS and for Windows is available to the user by selecting the **Help Menu**.

In order to specify the population for a simulation or optimization, the user would select the **Scenario Menu** at the screen shown in Figure 5. The **Scenario Menu**, shown in Figure 6, would then allow the user to select the **Select AFSs/Clusters** option. At the next menu (Figure 7), the user may then select between using AFSs or Clusters for the simulation.

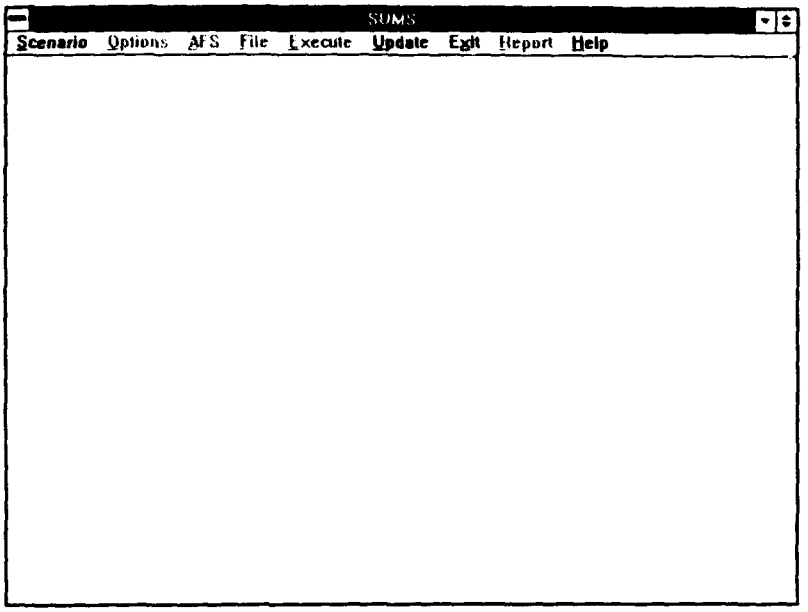

Figure 5. SUMS Menu Screen

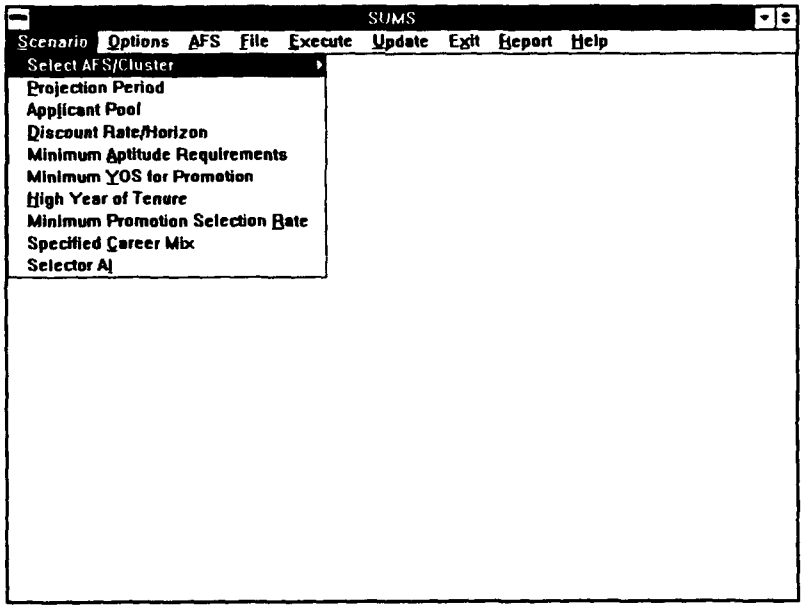

Figure 6. Scenario Menu: Define Population

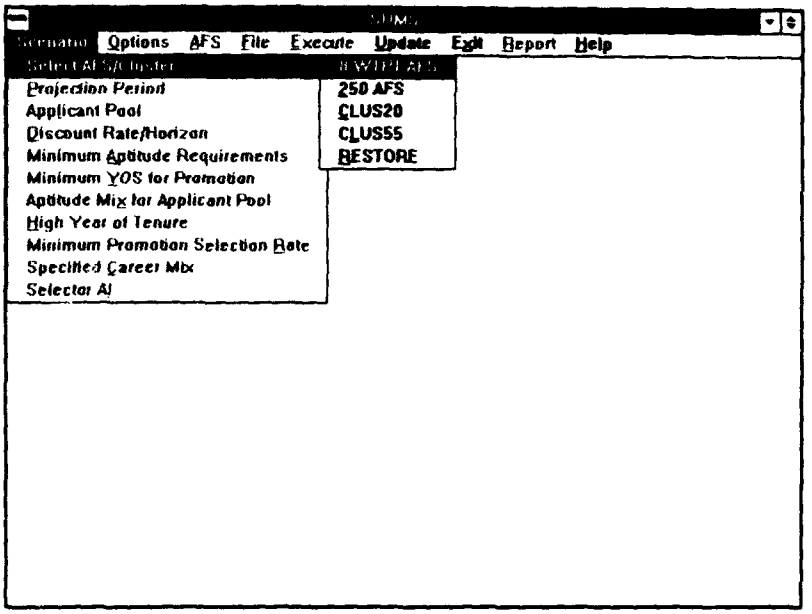

Figure 7. Select AFS/Cluster Menu

To perform force-level analysis at the 5-digit AFS level, the user may select the **250 AFS** option. The user may then select any combination or all of the AFSs included in SUMS. Only AFSs with entry-level openings could be included in SUMS. Appendix C contains information concerning AFSs not included in SUMS and explanations for the exclusions.

To specify the AFSs to be included in the simulation or optimization, the user selects the desired AFSs from the list provided (Figure 8). By default all AFSs are selected. The user may use the **Clear All** option to un-select all AFSs and then select specific AFSs using the mouse. The user may also use the **Select All** option to re-highlight all AFSs. After selecting the AFSs to be included in the population, the user should then select the **OK** option. The population for SUMS will now be defined as the selected AFSs. Selecting the **Cancel** option instead of the **OK** option would allow the user to respecify whether to use AFSs or Clusters for the simulation.

The user may also perform force-level analysis by selecting one of the clusters at the menu in Figure 7. The user may choose between two clusters of AFSs:

- **20 Selector Aptitude Index (Mechanical (M), Administration (A), General (G), Electronic (E)) Clusters** or
- **55 AFS Clusters.**

The user may select between the two different clusterings by clicking on the desired clustering. This cluster will then be used as the population for SUMS. Appendix C presents the methodologies used to develop these clusters and the AFSs contained in each cluster.

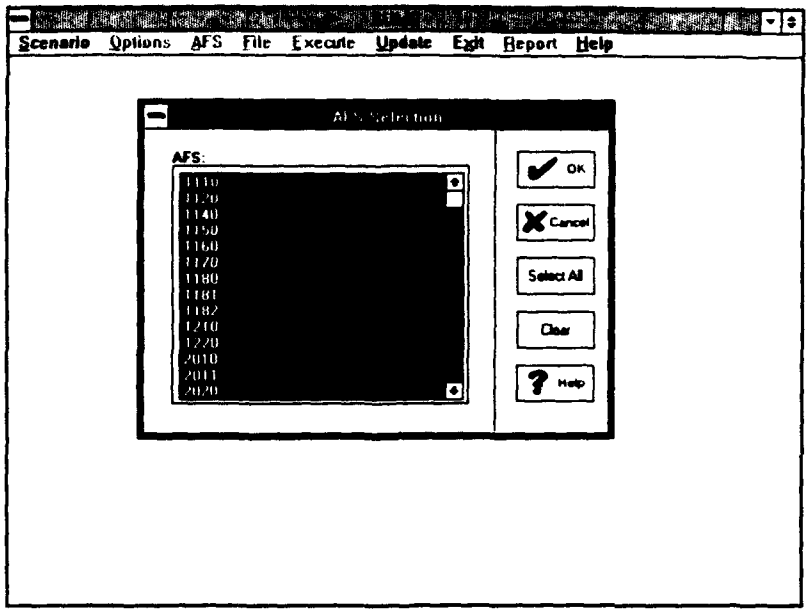

Figure 8. Select 250 AFS Selection Screen

The user may also select the **8 WTPT AFS** option (Figure 7). The user may specify any combination or all of the eight Walk Through Performance Test (WTPT) AFSs (Figure 9) from the Air Force Job Performance Measurement (JPM) research program (Hedge, 1984):

- **AFS 122x0** - Aircrew Life Support,
- **AFS 272x0** - Air Traffic Controller,
- **AFS 324x0** - Precision Measurement Equipment Laboratory,
- **AFS 328x0** - Communication and Navigation Systems,
- **AFS 423x5** - Aerospace Ground Equipment,
- **AFS 426x2** - Jet Engine Mechanic,
- **AFS 492x1** - Communication Systems Radio Operations, and
- **AFS 732x0** - Personnel Specialist.

To specify the AFSs to be included, the user clicks on the desired AFS (Figure 9), highlighting that AFS.

Once the population for SUMS has been defined using AFSs or clusters, the user may not redefine the population without exiting or restarting SUMS. If the user has defined the population using AFSs, the number of AFSs included in the population may not be increased or decreased. Once the user has specified the AFSs or Clusters to be used in the simulation or optimization, the user is then able to access all the parameters and options of SUMS, as well as execute a simulation or optimization.

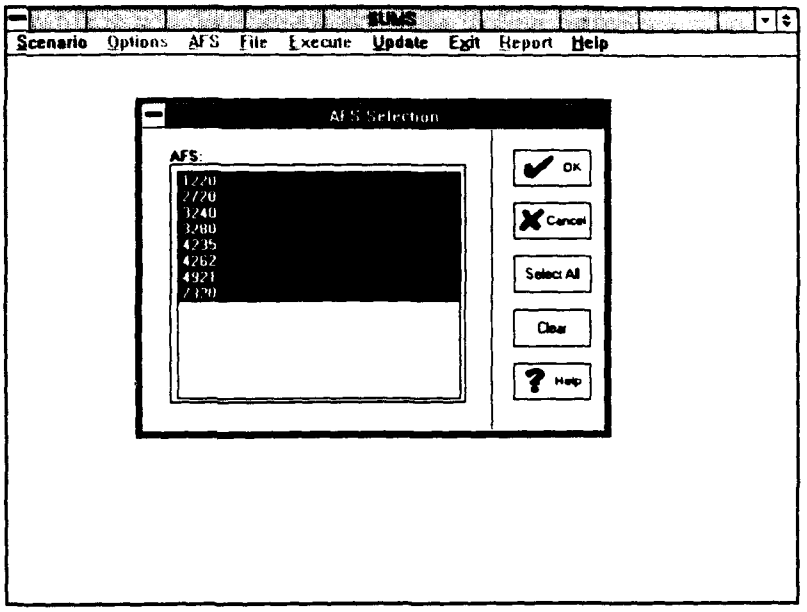

Figure 9. 8 WTPT AFS Selection Screen

The last option under **Select AFS/Cluster** is **RESTORE**. The **RESTORE** option loads in a previously setup scenario including the population definition. Scenarios are saved using the **Scenario Parameters File Name** option under the **File** menu.

SCENARIO

The **Scenario Menu** allows the user to access the parameters of a simulation scenario which are not AFS/Cluster specific. If the user does not access the **Scenario Menu**, the simulation or optimization will use default values for all the parameters available under this menu. From the **Scenario Menu**, presented in Figure 10, the user may access the following screens for the purpose of changing or viewing parameter values:

- **Projection Period,**
- **Applicant Pool,**
- **Discount Rate/Horizon,**
- **Minimum Aptitude Requirements,**
- **Minimum YOS for Promotion,**
- **High Year of Tenure,**
- **Minimum Promotion Selection Rates,**
- **Specified Career Mix,** and
- **Selector AI.**

Each screen for these parameters will display the default value(s) for the parameter. The user may view or revise any of the parameters shown on the menu presented in Figure 10. Each parameter screen will be discussed in detail.

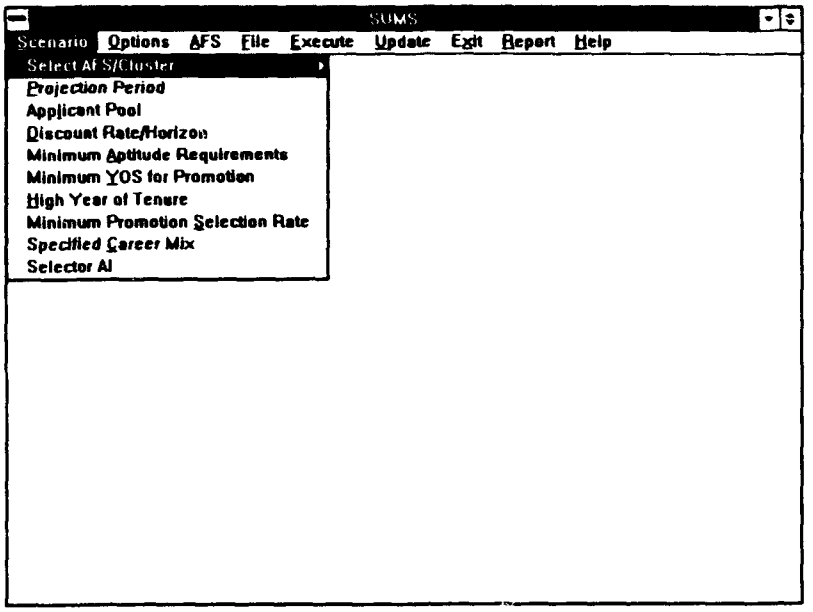

Figure 10. Scenario Menu

Projection Period

The **Projection Period Screen**, shown in Figure 11, allows the user to specify the number of years to be projected in the simulation. The minimum number of projection years allowed is 1 and the maximum allowed is 20. The number of projection years must be entered in integer numbers, e.g. 1, 2, 3, ..., 20. By default the simulation will include 2 projection years.

Applicant Pool

The **Applicant Pool Screen** (Figure 12) allows the user to specify whether to define the applicant pool size or to use the Airman Applicant Prediction System (AAPS) to produce both the size and quality distribution of the applicant pool (Stone, Turner, Looper, and Engquist, 1992b) from which accession will be drawn for each projection year of the simulation or optimization.

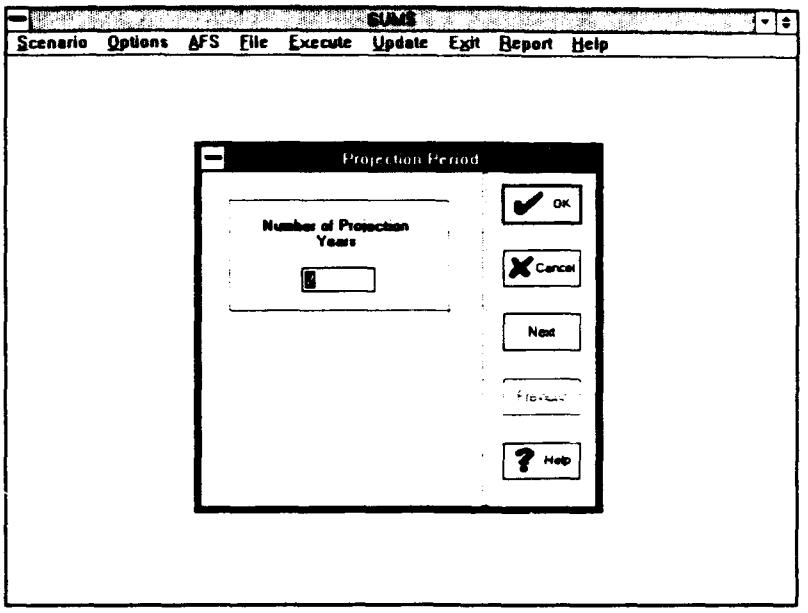

Figure 11. Projection Period Screen

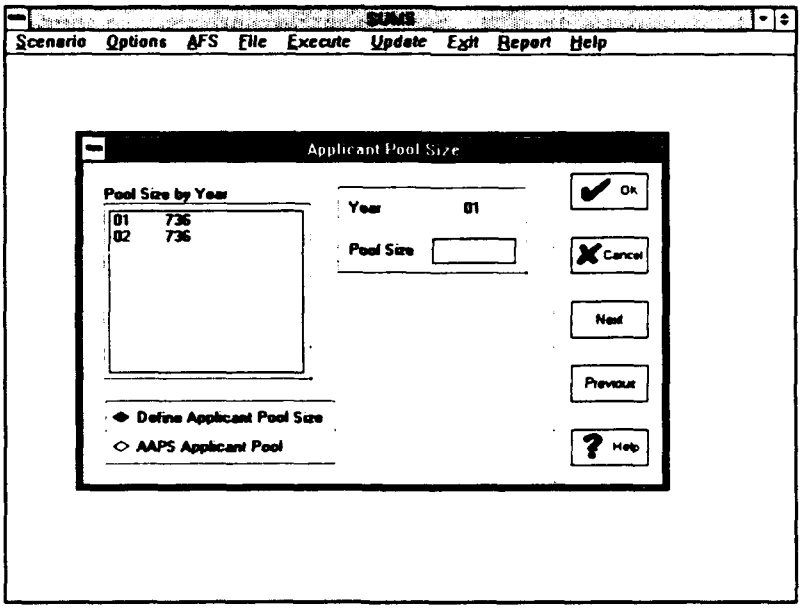

Figure 12. Applicant Pool Screen

By default, the **Define Applicant Pool Size** option will be employed. With this option, the user may specify the size of the applicant pool to be used for each of the projection years specified in the **Projection Period Screen**. The user may change any one of or all of the pool sizes. The quality distribution of the applicant pool will be determined using the quality distribution of the fiscal year (FY) 90 Military Entrance Processing Station (MEPS) applicant records. Applicant pools may vary in size for each year of a simulation. To change the size of an applicant pool, the user must select the year corresponding to the projection year to be changed from the box and then enter the new size of the new size of the applicant pool. This number must be an integer number greater than zero. Pool sizes too large or too small relative to the number of authorized positions in the population of the scenario will affect the validity of the simulation.

Default values for the applicant pool size for the **Define Applicant Pool Size** option are calculated as a function of the size of the force for the scenario, the separation rate (not including force-outs) for the specified force, and the proportion of the applicant pool which is qualified given the **Minimum Aptitude Requirements** for the Minimum G-score and Composite score. The size of the force for the scenario is determined by the population (AFSs or Clusters) specified by the user for the scenario. The separation rate is calculated as the number of separations from the initial inventory divided by the initial inventory of the population. The default applicant pool size is calculated by multiplying the separation rate, the initial inventory, and the reciprocal of the proportion of the applicant pool meeting the minimum aptitude requirements.

The user may choose to use AAPS to determine both the size and the quality mix of the applicant pool. The user may affect the parameters which AAPS uses to determine the size and distribution of the applicant pool. Detailed information regarding the methodology used by AAPS to determine the applicant pool may be found in Stone, Turner, Looper, and Engquist (1992b).

If the user elects to use the **AAPS Applicant Pool** option, the screen in Figure 13 would be the next to appear. At the **AAPS Model Parameters** screen (Figure 13), the user may specify the unemployment rate, and changes to the military to civilian wage ratio and recruiting resources. AAPS will determine the applicant pool size and distribution for each projection year of the simulation. Default values for the parameters of AAPS assume a 13% unemployment rate (determined from the average unemployment rate in AAPS) and no change in the wage ratio and recruiting resources.

Discount Rate/Horizon

The **Discount Rate/Horizon Screen** allows the user to specify the discount rate to be used in the simulation and the horizon for applying that discount rate, Figure 14. The discount rate will be used in the computation of expected net return and any other expected values or costs that will be required in the simulation. The horizon is the number of years into the future

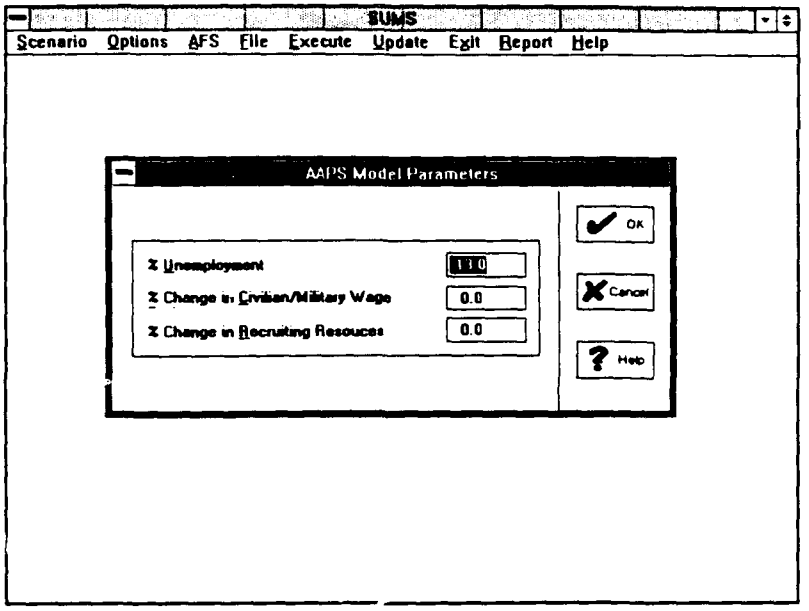

Figure 13. AAPS Model Parameters Screen

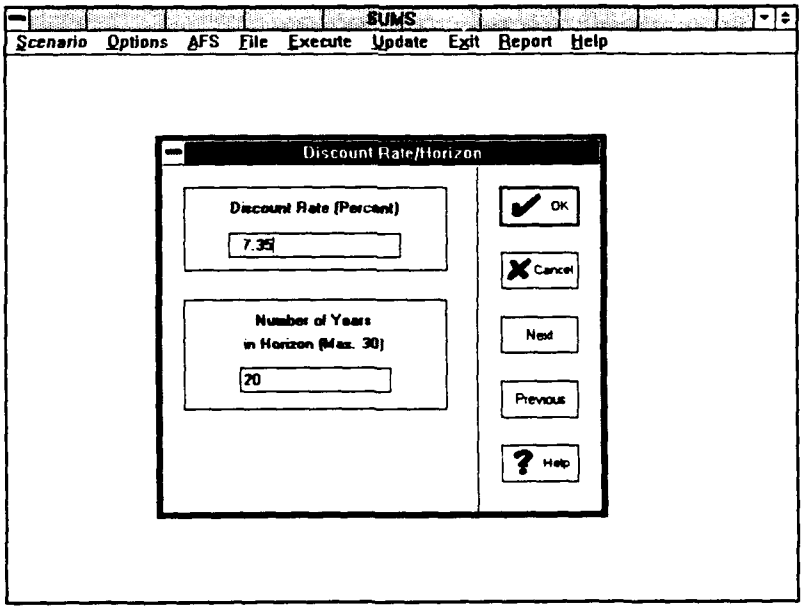

Figure 14. Discount Rate/Horizon Screen

to be used in the computation of expected net return and any other expected values or costs that will be required.

The rate specified for the discount rate must be greater than or equal to 0.00%. The horizon must be entered in integer years greater than one year and less than or equal to 30 years. By default, the discount rate is specified as 7.35% and the horizon is 20 years. The default discount rate is a 10+ year Treasury bill rate from the August 17, 1992, Wall Street Journal. A 20 year horizon is assumed based on the continuation rates from the Uniform Airman Records (UAR) file for June 1990. Based on the June 1990 UAR file, most retirements for enlisted personnel occurred at the 20 year of service (YOS) point.

Minimum Aptitude Requirements

The **Minimum Aptitude Requirements Screen** allows the user to specify the minimum aptitude requirements for all entering accessions, Figure 15. These minimum aptitude requirements are applied to all applicants in the specified applicant pool. An applicant not meeting the specified minimum aptitude requirements will not be considered as a possible entering accession by the simulation. These requirements effectively reduce the number of people in the available applicant pool from which accessions may be drawn. Overall minimum aptitude requirements do not vary by AFS/Cluster or by projection year.

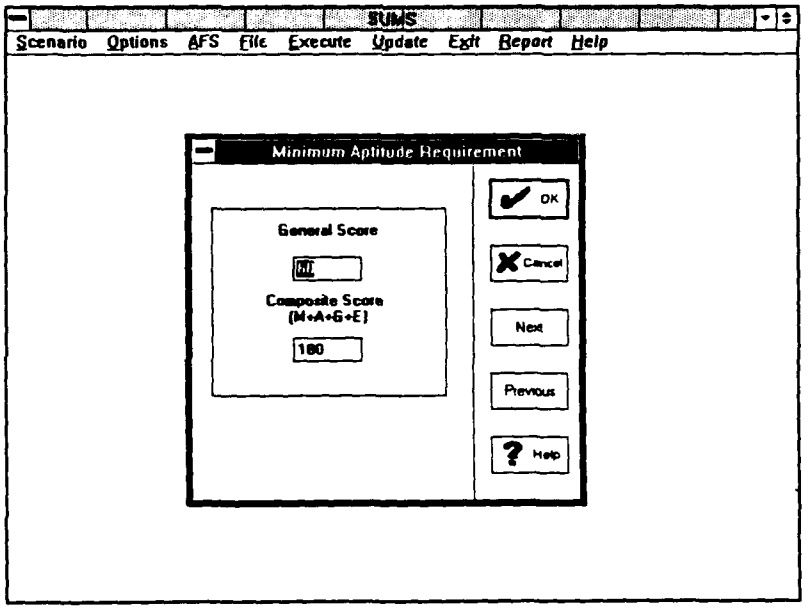

Figure 15. Minimum Aptitude Requirements Screen

The user may specify the minimum General (**G**) score allowed for any entering accession, as well as the minimum Composite percentile score for any entering accession. The minimum Composite score is the sum of the Mechanical (**M**), Administrative (**A**), General (**G**), and Electronic (**E**) scores for any applicant (possible scores for each test range between 10 and 99, with a range for the Composite score between 40 and 396). To change the minimum aptitude requirements, the user must select the appropriate box and enter the new minimum score. The score entered must be an integer number. By default the minimum **G**-score for entering accessions is 60 and the minimum Composite score is 180.

Minimum YOS for Promotion

The **Minimum YOS for Promotion Screen** allows the user to specify the minimum number of years of service (YOS) necessary in a particular grade to be eligible for promotion to the next grade, Figure 16. Only personnel satisfying the YOS requirement will be considered for promotion by the simulation. The minimum YOS for promotion requirement varies only by grade. It does not vary by AFS/Cluster or by projection year.

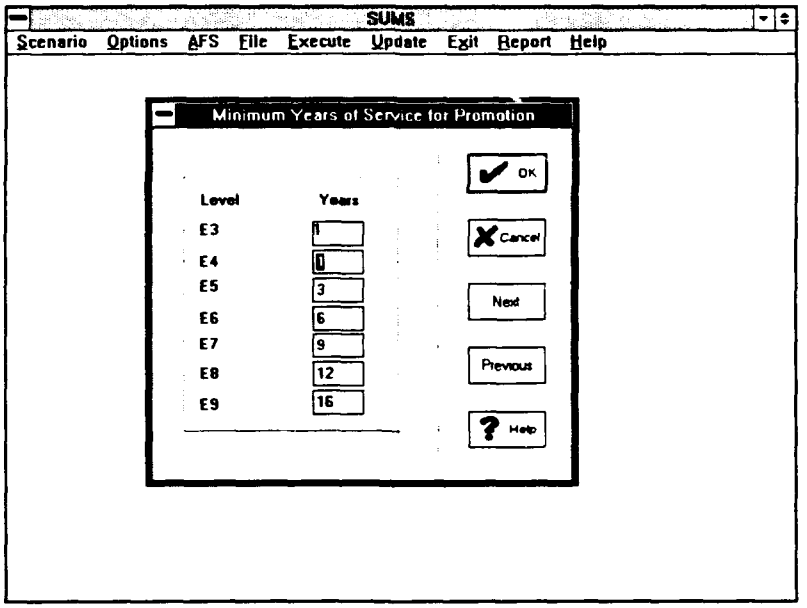

Figure 16. Minimum YOS for Promotion Requirements

The user may change any or all of the YOS requirements for promotion. To change the YOS requirements, the user must select the box corresponding to the grade YOS requirement to be changed. The user may then enter the new YOS requirement. The new

YOS requirement must be an integer number greater than or equal to zero. By default the minimum YOS for promotion by grade is:

- **1** YOS for promotion from grade **E3** to grade **E4**,
- **3** YOS for promotion from grade **E4** to grade **E5**,
- **6** YOS for promotion from grade **E5** to grade **E6**,
- **9** YOS for promotion from grade **E6** to grade **E7**,
- **12** YOS for promotion from grade **E7** to grade **E8**, and
- **16** YOS for promotion from grade **E8** to grade **E9**.

Average YOS for promotions were obtained from the Air Force Military Personnel Center (AFMPC). Minimum YOS for promotions from grades E1 to E2 and E2 to E3 are assumed to be zero, i.e., these promotions are always assumed to occur within the first YOS determined from the Uniform Airman Records (UAR) file for June of 1990. The minimum default values for promotion to grades E4 to E9 were determined from the average YOS for promotions adjusted for the distribution of grades from the UAR file for June of 1990.

High Year of Tenure (HYT)

The **High Year of Tenure (HYT) Screen**, shown in Figure 17, allows the user to specify the maximum amount of time that personnel may stay in the service based on his grade. Airmen with a YOS value greater than the maximum HYT parameter specified for that grade will be forced-out of the service.

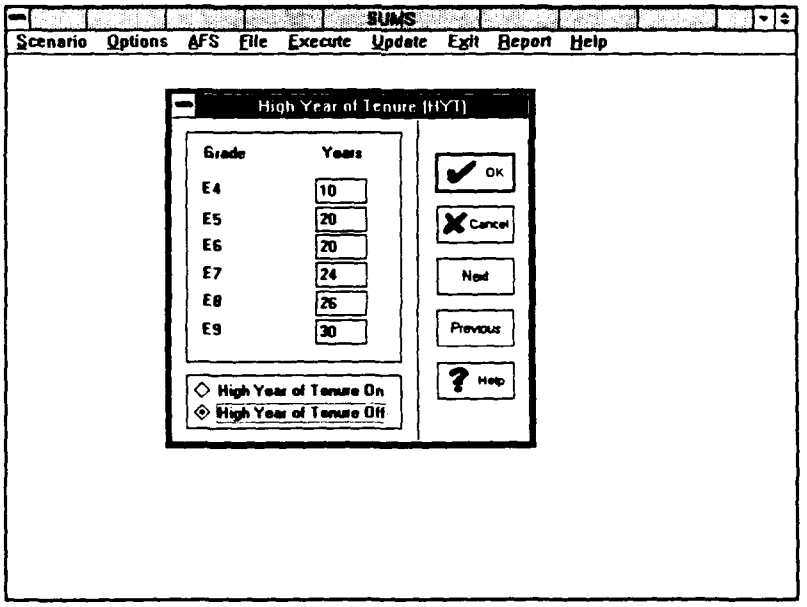

Figure 17. High Year of Tenure (HYT) Screen

The default value is to not employ this option. The user may employ the **HYT** option by selecting **High Year of Tenure On** at the bottom of the screen. The user may then specify the maximum YOS values allowed for grades E4 through E9. Airmen remaining in any grade with more than the allowed YOS at the end of the projection year will be forced-out. Default values for grades E4 through E9 were obtained from the October 1991 Total Objective Plan for Career Airmen Personnel (TOPCAP,1991) document. Default parameters for the HYT option are as follows:

- **10** YOS maximum for grade **E4**,
- **20** YOS maximum for grade **E5**,
- **20** YOS maximum for grade **E6**,
- **24** YOS maximum for grade **E7**,
- **26** YOS maximum for grade **E8**, and
- **30** YOS maximum for grade **E9**.

Minimum Promotion Selection Rate (MPSR)

The **Minimum Promotion Selection Rate (MPSR) Screen** (Figure 18) allows the user to specify the minimum promotion rate that can be used in the simulation for promoting airmen

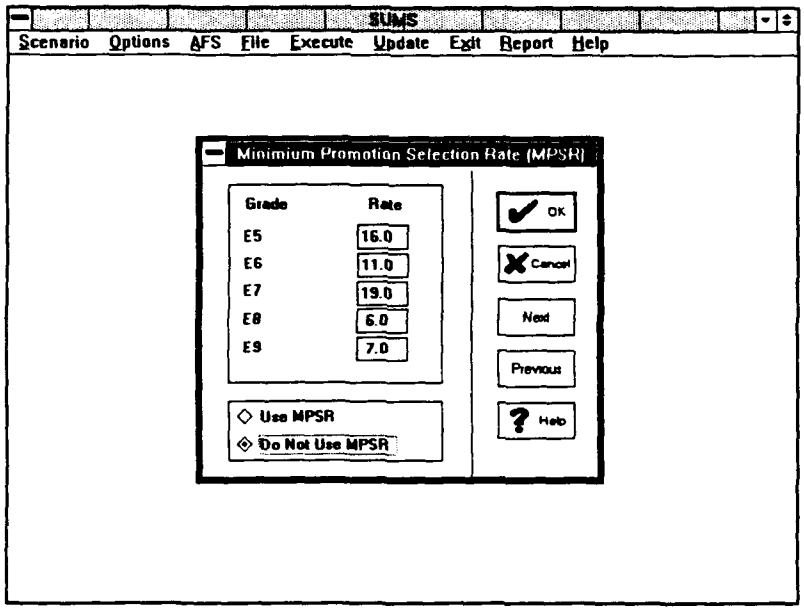

Figure 18. Minimum Promotion Selection Rate Screen

from one grade to the next. This option would employ the minimum promotion rate specified for one grade to the next if the promotion rate for that grade, calculated using the

user specified method of promotion from the **Promotion Screen**, fell below the minimum promotion rate specified on this screen. The default value is to not employ this option. The user may employ the **MPSR** option by selecting **Use MPSR** at the bottom of the screen. The user may then specify the *minimum promotion* selection rates for promotion to grades E5 through E9. Default values for promotion to grades E5 through E9 were obtained from the October 1991 TOPCAP document. Default minimum promotion selection rates for promotion to grades E5 through E9 are as follows:

- **16%** for promotion to grade **E5**,
- **11%** for promotion to grade **E6**,
- **19%** for promotion to grade **E7**,
- **6%** for promotion to grade **E8**, and
- **7%** for promotion to grade **E9**.

Specified Career Mix

The **Specified Career Mix Screen**, shown in Figure 19, allows the user to specify the experience distribution of the force. The career mix of the force may be defined in terms of the percentage of the total force that airmen in grades E5 through E9 constitute. The career mix

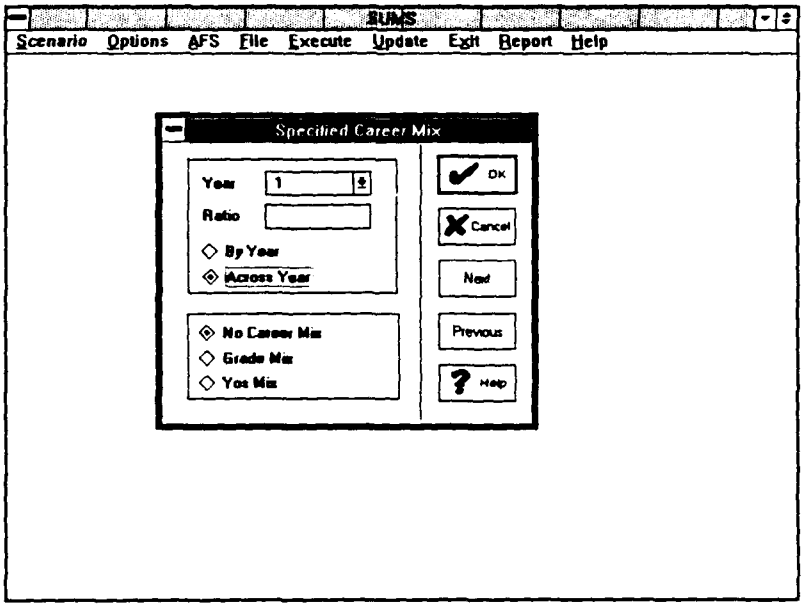

Figure 19. Specified Career Mix Screen

may also be defined as the percentage of the force with five or more YOS. If this option is employed by the user, at the end of each projection year in the simulation, the career mix

of the force will be assessed in the user specified terms (grade or YOS). If the resulting career mix is above or below the user specified career mix, airmen will be forced-out of the service in order to meet the specified career mix objective.

The default value is to not employ this option. The user may employ this option by selecting the **Grade Mix** option or **YOS Mix** option at the bottom of the screen. The career mix may be specified for each projection year of the simulation. The user may select to specify the career mix **By Year** or **Across Years**. Default values of 52.2% for the **Grade Mix** and 53.0% for the **YOS Mix** were obtained from the October 1991 TOPCAP document. The default values for **Grade Mix** and **YOS Mix** are co...unt for each year of the simulation. Values for the specified career mix are force level objectives and are not meant to be used as career mix requirements for individual AFSs or Clusters.

Selector Aptitude Index (AI)

The **Selector AI Screen** shown in Figure 20 allows the user to define the methodology used to group Armed Services Vocational Aptitude Battery (ASVAB) subtest scores into Selector AI scores. The default value is to not employ this option. The user may specify which AI score to redefine, either Mechanical (M), Administrative (A), General (G), or Electronic (E), using the **Composite** box. Next the user may specify the subtest scores to be used in the formulation of the new AI composite score and the weighting of each subtest score. Scores for each subtest range between 20 and 80. Weights must be specified in positive integer numbers. The user may choose between these subtests:

- General Science (GS)
- Arithmetic Reasoning (AR)
- Word Knowledge (WK)
- Paragraph Comprehension (PC)
- Numerical Operations (NO)
- Coding Speed (CS)
- Auto and Shop Information (AS)
- Mathematics Knowledge (MK)
- Mechanical Comprehension (MC)
- Electronics Information (EI)

Current MAGE weights are:

- M = MC + GS + 2*AS
- A = NO + CS + WK + PC
- G = WK + PC + AR
- E = AR + MK + EI + GS

Once the AI composite(s) has been defined, SUMS will then determine the new quality distribution of the applicant pool using the new composite(s). The newly defined composite(s) will be used in the allocation of accessions from the applicant pool for each year of the simulation. New productive capacity schedules (see Appendix A) based on the new composite(s) will also be constructed in SUMS. Data from Phase 1 test scores of the WTPT data (Hedge, 1984) were used to determine the relationships between subtest scores, experience, and productive capacity.

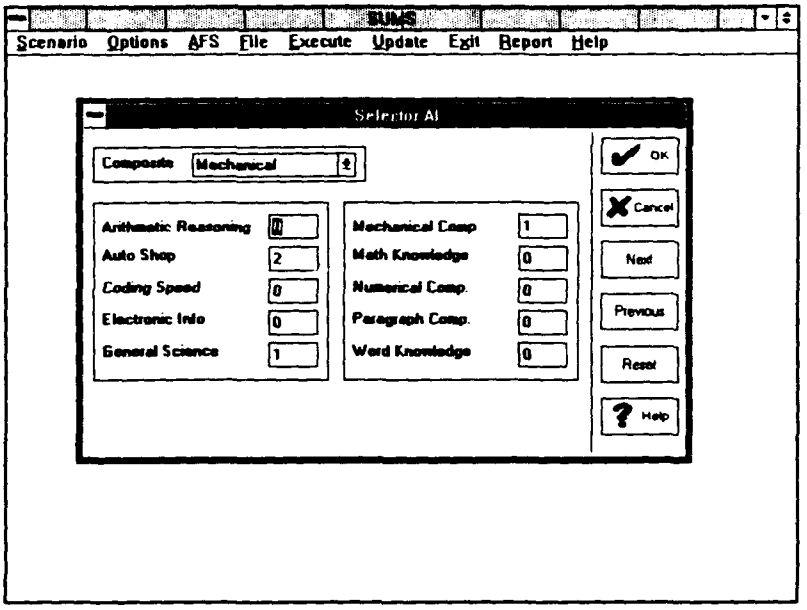

Figure 20. Selector AI Screen

These new productive capacity schedules will be used to determine the productive capacity of all airmen assessed during each year of the simulation. Productive capacity of personnel already in the force inventory before the first year of the simulation will be determined using the default productive capacity schedules based on the standard definitions of the composite AI scores.

OPTIONS

The **Options Menu**, displayed in Figure 21, allows the user access to different methodologies for determining promotions and allocating accessions. This menu also allows the user to view/revise the cost and value parameters to be used in the simulation. Specifically, the **Options Menu** allows the user to access the following options:

- **Promotion**,
- **Accession**, and
- **Costs/Values**.

Each screen or menu for these options/changes will display the default options/values. The user may view and/or revise any of the values accessible from the menu presented in Figure 21. Each option/value screen will be discussed in detail.

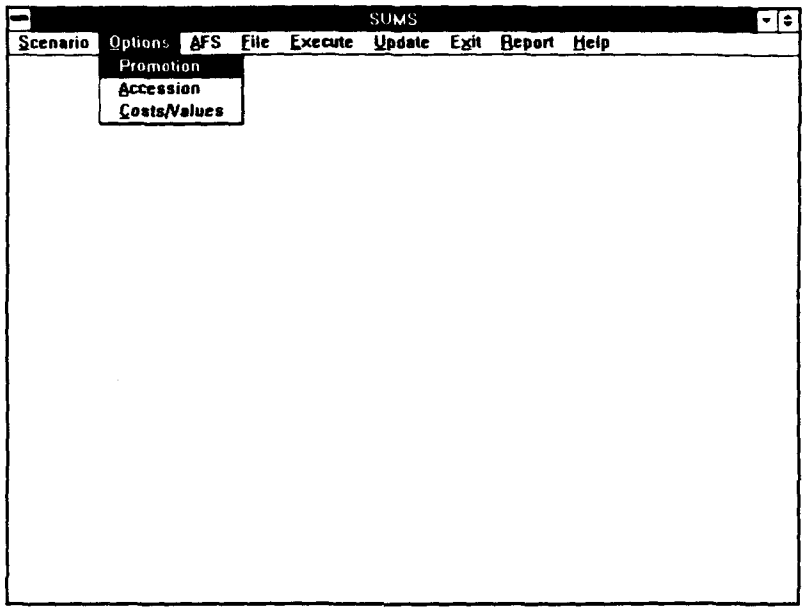

Figure 21. Options Menu

Promotion

The **Promotion Screen** allows the user to select the type of promotion system to be utilized by the simulation, Figure 22. There are three options for the methodology to be used to promote enlisted personnel during the scenario:

- **Promote to Fill within AFSs**,
- **Equal Selection Opportunity (ESO)**, and
- **Two-Tier Promotion**.

To specify the type of promotion to be used in the simulation, the user must select the desired method of promotion. By default the simulation will utilize the **Equal Selection Opportunity (ESO)** method.

Promote to Fill within AFSs Method promotes personnel by AFS at a rate which will fill the openings created by natural attrition within the AFS/Cluster. This rate will vary by AFS/Cluster since the number of openings and the eligible promotion population vary by AFS/Cluster.

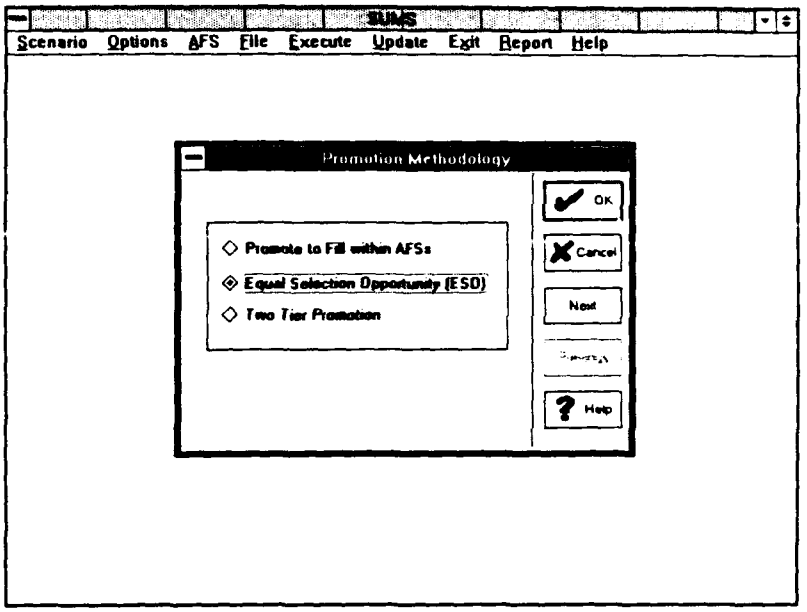

Figure 22. Promotion Screen

Equal Selection Opportunity (ESO) Method promotes personnel across all AFSs/Clusters at a single rate. This rate will be the same across AFSs/Clusters by grade. This method does not necessarily insure that all needed promotions within AFSs/Clusters by grade will be met, resulting in potential shortages and overages. The single promotion rate represents the proportion of the total eligible population (sum of all eligible populations across AFSs/Clusters) necessary to fill all openings (sum of all openings across AFSs/Clusters). For example, if 1000 openings exist across AFSs/Clusters and the eligible population across AFSs/Clusters equals 1500, the single promotion rate applied each AFS/Cluster is equal to (1000/1500) or 0.67.

Two-Tier Promotion Method first determines the promotion rate using the same methodology as used to determine the ESO promotion rates. However, once the ESO promotion rates are determined, the promotion rates for a "second tier" of AFSs/Clusters is increased by 5.0%. AFSs/Clusters in the "second tier" were determined from the AFSs eligible for Selective Reenlistment Bonus (SRB) as of September 1992 data obtained from the Air Force Military Personnel Center (AFMPC) Retention Group. If the user selects the **Two-Tier Promotion** method, the user will be able to specify the AFSs/Clusters to be included in the "second tier" at the **Two-Tier Selection Screen** shown in Figure 23. AFSs/Clusters highlighted at this screen will be included in the "second tier" for promotion.

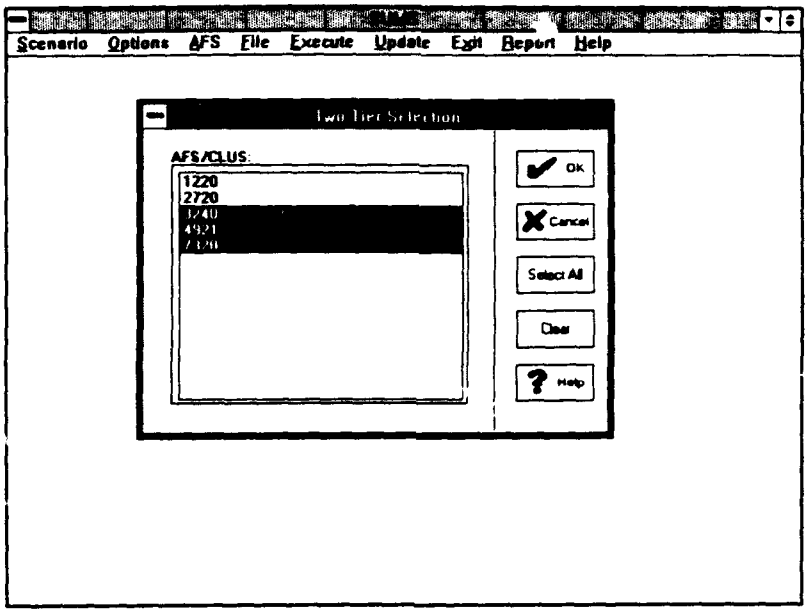

Figure 23. Two-Tier Selection Screen

Accession

The **Accession** option allows the user to select the methodology for allocating accessions which will be used by the simulation, Figure 24. This option also allows the user to specify the objective to be maximized or minimized for an optimization. Any of the methods may be selected for the optimization, with the exception of the **Random Arrival** method. By default, the simulation (or optimization) will use the **Maximize Expected Total Net Return** Method. A more detailed explanation of each method is provided in Appendix A. The user may select from eight accession allocation methodologies:

- **Random Arrival**,
- **Maximize Expected Total Net Return**,
- **Maximize Total Productive Capacity**,
- **Maximize Total Value**,
- **Minimize Total Cost**,
- **Maximize Expected Total Productive Capacity**,
- **Maximize Expected Total Value**, and
- **Minimize Expected Total Cost**.

Random Arrival Method uses a random procedure for determining when, and the order in which, applicants from the specified applicant pool become available to be considered as a possible accession. This method attempts to represent the way in which applicants appear at the MEPS as a random occurrence. Accessions are allocated to AFSs/Clusters as they randomly arrive at the

MEPS on the relative basis of need by each AFS/Cluster, without regard to the aptitude distribution of future applicants.

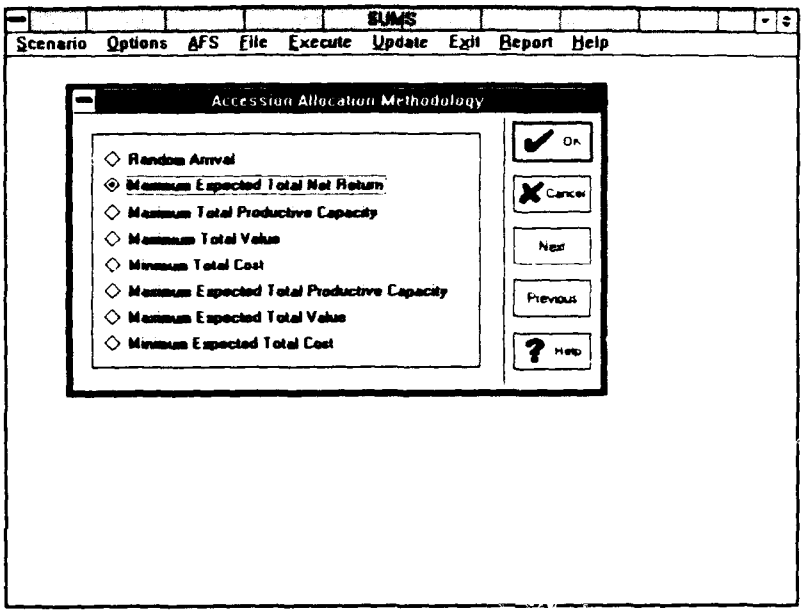

Figure 24. Accession Screen

Maximize Expected Total Net Return Method uses the expected net return calculated for each aptitude cell (of the eligible applicant pool) for each AFS/Cluster to allocate accessions in order to maximize total system expected net return for each projection year. Total system expected net return is equal to the sum of expected net return across accessions across AFSs. Expected net return is equal to the expected present discounted value of the flow of accruable value to the Air Force, net of cost, from an applicant entering a particular AFS/Cluster projected over a given horizon accounting for the probability of continuation from one YOS to the next.

Maximize Total Productive Capacity Method uses the productive capacity calculated for each aptitude cell (of the eligible applicant pool) for each AFS/Cluster to allocate accessions in order to maximize total system productive capacity for each projection year. The productive capacity for an applicant is equal to the sum of the productive capacity to be accrued each year over a given horizon by entering a particular AFS/Cluster.

Maximize Total Value Method uses the total value calculated for each aptitude cell (of the eligible applicant pool) for each AFS/Cluster to allocate accessions in order to maximize total system value for each projection year. The total value for an applicant is equal to the discounted present value of the flow of

value (or worth) to be accrued from each year of service over a given horizon by entering a particular AFS/Cluster.

Minimize Total Cost Method uses the total cost calculated for each aptitude cell (of the eligible applicant pool) for each AFS/Cluster to allocate accessions in order to minimize total system cost for each projection year. The total cost for an applicant is equal to the discounted present value of the flow of cost to be accrued from each year of service over a given horizon by entering a particular AFS/Cluster.

Maximize Expected Total Productive Capacity Method uses the expected productive capacity calculated for each aptitude cell (of the eligible applicant pool) for each AFS/Cluster to allocate accessions in order to maximize total system expected productive capacity for each projection year. The total expected productive capacity for an applicant is equal to the sum of the expected productive capacity to be accrued over a given horizon by entering a particular AFS/Cluster. Expected productive capacity is equal to the product of the probability of remaining in service through the *n*th YOS times the productive capacity of the individual in the *n*th YOS (Stone et al., 1992a).

Maximize Expected Total Value Method uses the expected total value calculated for each aptitude cell (of the eligible applicant pool) for each AFS/Cluster to allocate accessions in order to maximize total system expected value for each projection year. The total expected value for an applicant is equal to the present discounted expected value of the flow of value (or worth) to be accrued from each year of service over a given horizon by entering a particular AFS/Cluster. Expected value equals the product of the probability of remaining in service through the *n*th YOS times the value of the individual in the *n*th YOS.

Minimize Expected Total Cost Method uses the expected total cost calculated for each aptitude cell (of the eligible applicant pool) for each AFS/Cluster to allocate accessions in order to minimize total expected system cost for each projection year. The total expected cost for an applicant is equal to the present discounted expected value of the flow of cost to be accrued from each year of service over a given horizon by entering a particular AFS/Cluster. Expected cost for the *n*th YOS equals the product of the probability of remaining in service through the *n*th YOS times the cost of the individual in the *n*th YOS.

Costs/Values

The **Costs/Values** option (Figure 25) allows the user to access the screens which provide the ability to specify the percentage change expected to occur in costs and values in

each projection year of the simulation. Actual costs and values vary by AFS/Cluster. The percentage changes in these costs/values vary only by year of projection, and not by AFS/Cluster. The user may specify the percentage change in the following costs/values:

- **Separation**,
- **Regular Military Compensation (RMC)**,
- **Basic Military Training (BMT)**,
- **On-the-Job Training (OJT)**,
- **Technical Training**,
- **Service State**, and
- **Retirement Accrual**.

All of the costs and values shown on this screen are automatically included in the calculation of costs and values in the simulation, with the exception of **Retirement Accrual** costs. The user must specify to use retirement accrual costs in the calculation by selecting the **Retirement Accrual** box. The retirement accrual value is shown in terms of a fraction of RMC.

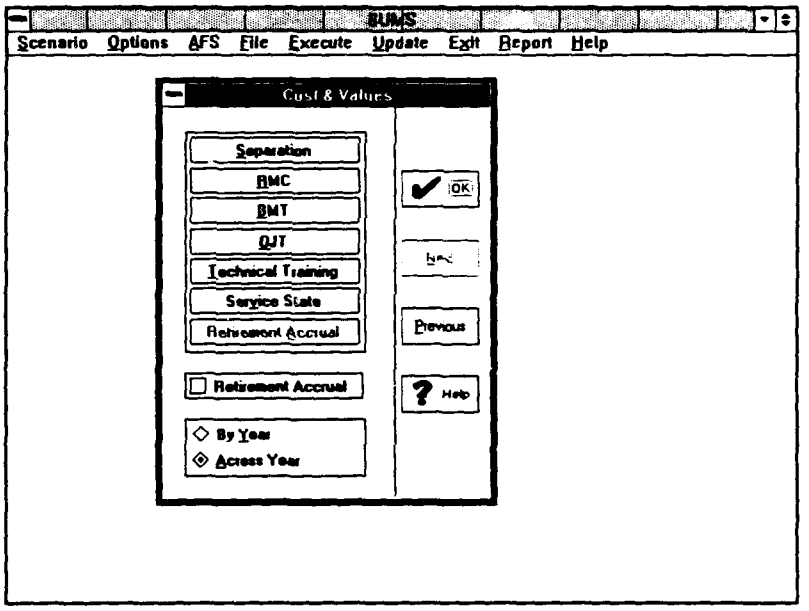

Figure 25. Costs/Values Screen

At this screen, for each cost or value selected the user may choose either to vary the percentage change by projection year or to set the percentage change the same across all projection years by selecting the appropriate option at the bottom of the screen. To view or revise the percentage change in any of these costs/values, the user must select the appropriate cost/value from the screen shown in Figure 25. The specific cost/value menu

for that cost/value selected will then appear. If the user has not selected the **Retirement Accrual** box, then the user will not be allowed to view or revise the values for **Retirement Accrual**.

The next screen to appear will display the values for the selected cost/value parameter either by or across projection years. If the user had specified to vary costs **By Year** and had then selected **Separation** costs to view or revise, the screen shown in Figure 26 would appear. The number of projection years shown at this screen will correspond to the number of projection years specified at the **Projection Period Screen**. By selecting the line for the appropriate projection year and entering the percentage change in the **Percent** box, the user may vary the percentage change in the cost/value by projection year. The same method would be used to view or revise and cost/value parameter by year.

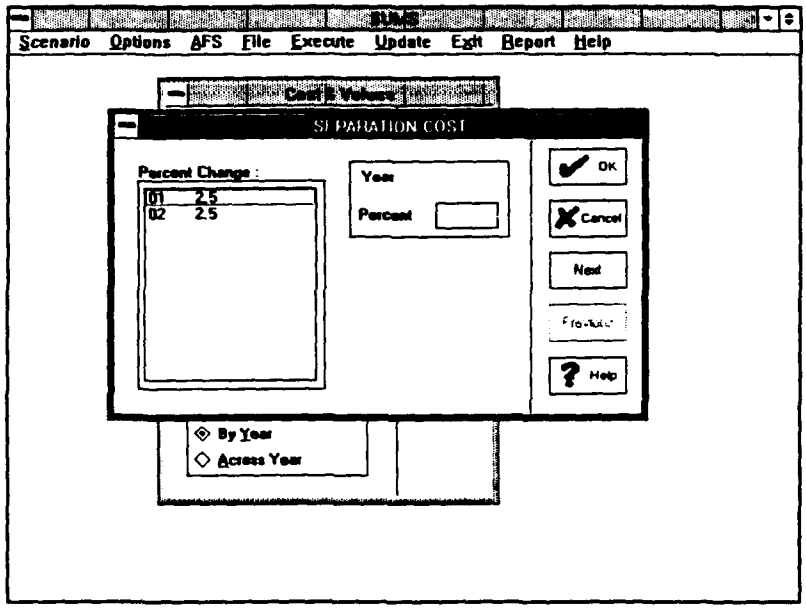

Figure 26. Separation Costs -- By Year

If the user had specified a percentage change **Across Years** and then selected **Separation** costs to view or revise, the next screen to appear would be the screen shown in Figure 27. At this screen, the user may then enter the new percentage change. The same method would be used to view or revise any cost/value parameter across years.

The percentage changes entered may reflect an increase or decrease in costs/values. An increase will be entered as a positive percentage and a decrease will be entered as a negative (-) percentage. By default the simulation assumes the following percentage changes for all projection years.

- Separation Costs +2.5%,
- RMC +3.0%,
- BMT Costs +2.5%,
- OJT Costs +6.0%,
- Technical Trng Costs +6.0%,
- Service State Values +5.0%, and
- Retirement Accrual +42.0%.

Percentage increases for Separation, BMT, OJT, and Technical Training costs were taken from the FY90 Air Training Command (ATC) Cost Factors Manual (1990). The percentage increase in RMC uses the authorized January 1992 increase in RMC (Enlisted Retention Report of 30 June 1991). The increase in service state values was assumed to follow the average increase in the earnings and compensation over the last 1979 to 1989 time period (Statistical Abstract of the United States, 1990). The fraction of RMC for the retirement accrual value was obtained from Palmer and Osbaldeston (1988).

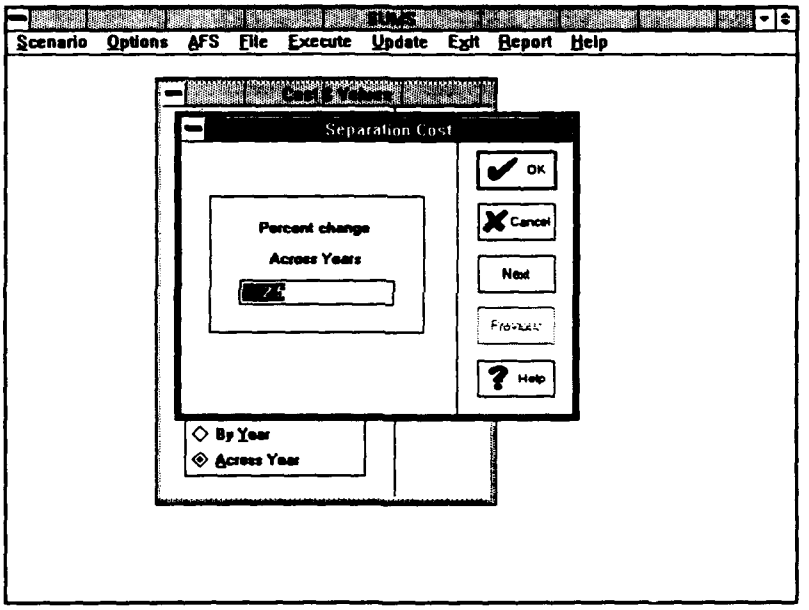

Figure 27. Separation Costs -- Across Years

AFS

The **AFS Menu**, shown in Figure 28, allows the user to specify AFS/Cluster parameters
which are AFS/Cluster specific. The following parameters may be accessed from this menu:

- **Minimum Selector AI Requirements,**
- **Minimum Manning Requirements,**
- **Manning Level Changes,**
- **Maximum Force-out Requirements,**
- **Recruit Goal,**
- **Reenlistment/Loss Model**, and
- **Productive Capacity**.

The user may set the parameters only for the AFSs/Clusters specified in the population for SUMS. If the user does not access the **AFS Menu**, the simulation will use default values for all AFS/Cluster specific parameters.

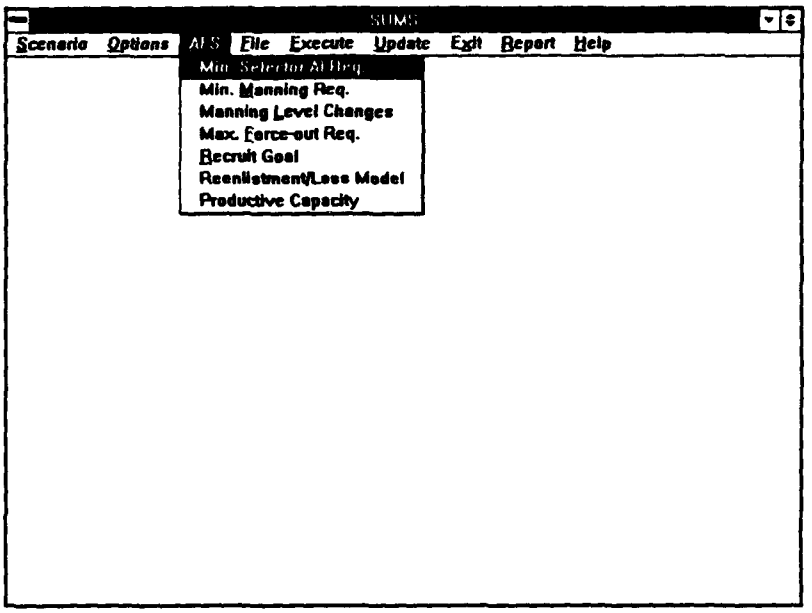

Figure 28. AFS Menu

Minimum Selector AI Requirements

The **Minimum Selector AI Requirements Screen**, shown in Figure 29, allows the user to specify the Minimum Selector Aptitude Index (AI) score for each AFS/Cluster of any entering accession. Only applicants meeting the minimum Selector AI for any AFS/Cluster will be considered as possible entering accessions for that AFS/Cluster by the simulation. The user may specify both the Selector AI for any AFS/Cluster and the minimum score for that Selector AI for any entering accession. The minimum Selector AI requirements do not vary by projection year. The user may select between four Selector AIs:

- Mechanical (**M**),
- Administrative (**A**),
- General (**G**), and
- Electronic (**E**).

Scores for the Selector AIs may range between 10 and 99. The screen shown in Figure 29 will display the default Selector AIs and minimum scores for the AFSs/Clusters specified by the user on the Select AFSs/Clusters screen. To change any Selector AI or its minimum score, the user must first select that AFS/Cluster from the box or enter the number of the AFS. The user may then enter the new Selector AI, or the new minimum score, or both.

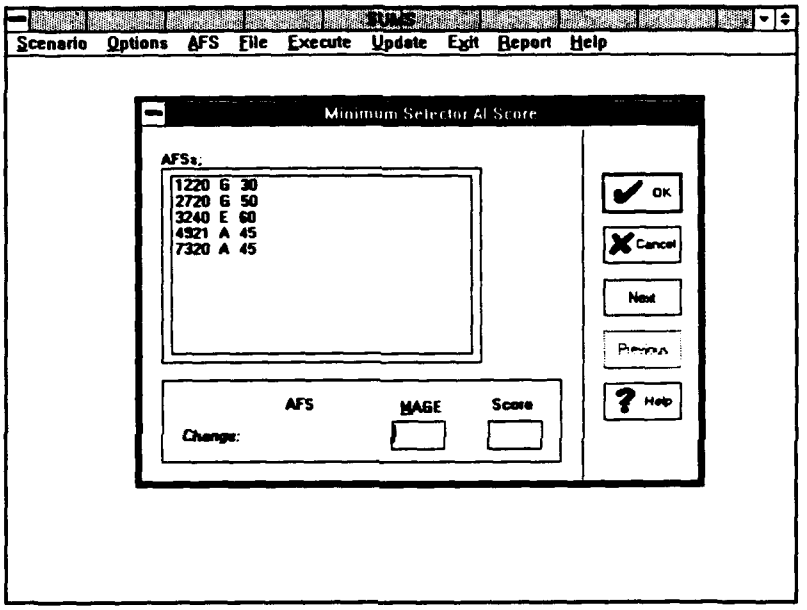

Figure 29. Minimum Selector AI Screen

SUMS will ignore a Selector AI requirement for a particular AFS/Cluster if the restriction is below the overall minimum aptitude requirement specified by the user on the **Minimum Aptitude Requirements Screen** from the **Scenario Menu**. For example, if the user had specified a minimum **G**-score of 60 for accessions at the **Minimum Aptitude Requirements Screen**, and then specified a minimum Selector AI of **G**-30 for any AFS/Cluster, the minimum Selector AI for that AFS/Cluster would be ignored by SUMS. All applicants with a score less than 60 had already been removed from the pool. The individual AFS/Cluster aptitude restrictions must be above the overall minimums to be effective.

Minimum Manning Requirements

The **Minimum Manning Requirements Screen**, shown in Figure 30, allows the user to specify how the minimum manning requirements will be changed. Minimum manning requirements ensure that each AFS/Cluster is able, at least partially, to meet its desired accession goals. Accessions are allocated to ensure that minimum manning requirements for each AFS/Cluster are met based on the AFS/Cluster-specific demand for accessions and the availability of accessions to meet the minimum manning levels across AFSs/Clusters. These minimum manning requirements will be satisfied first by the simulation. The accession allocation methodology selected by the user on the **Accession Screen** will be used to allocate accessions subject to meeting the minimum manning requirements. Once the minimum manning requirements are satisfied, the residual applicant pool, if existing, will then be allocated using the unconstrained accession allocation methodology.

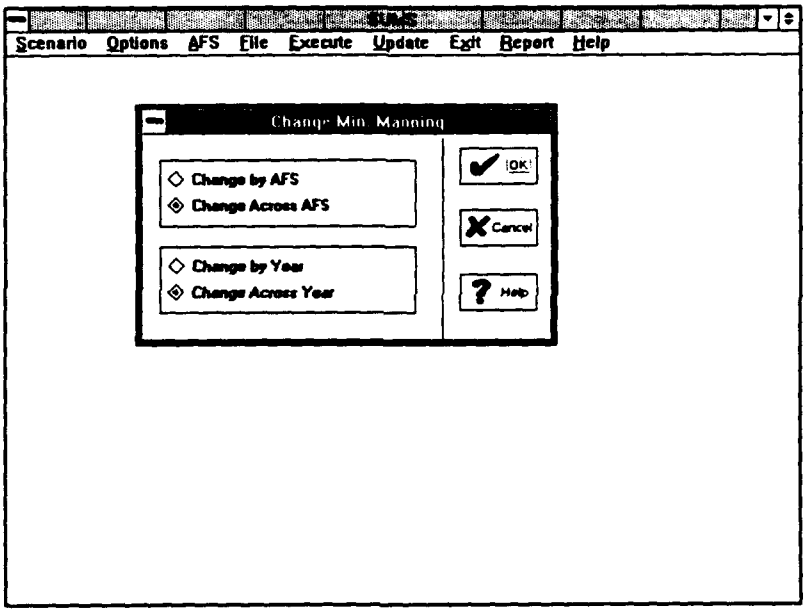

Figure 30. Minimum Manning Requirements Screen

The user may specify minimum manning requirements which vary by or across AFSs/Clusters and by or across years. The user many specify minimum manning requirements in percentages that vary between 0% and 200%. By default, minimum manning requirements are established at 100% across all AFSs/Clusters and projection years. The user has four possible options for changing the minimum manning requirements:

- **Change By AFS, Change By Year**
- **Change By AFS, Change Across Year**
- **Change Across AFS, Change By Year**
- **Change Across AFS, Change Across Year**

Manning Level Changes

The **Manning Level Changes Screen**, shown in Figure 31, allows the user to specify the percent change in manning levels by AFS/Cluster, grade and projection year for a simulation. Manning levels may also be specified for an optimization. However, manning levels for an optimization may only be specified by or across AFSs/Clusters, they may not vary by year or grade. Manning levels represent the number of personnel required in each grade for

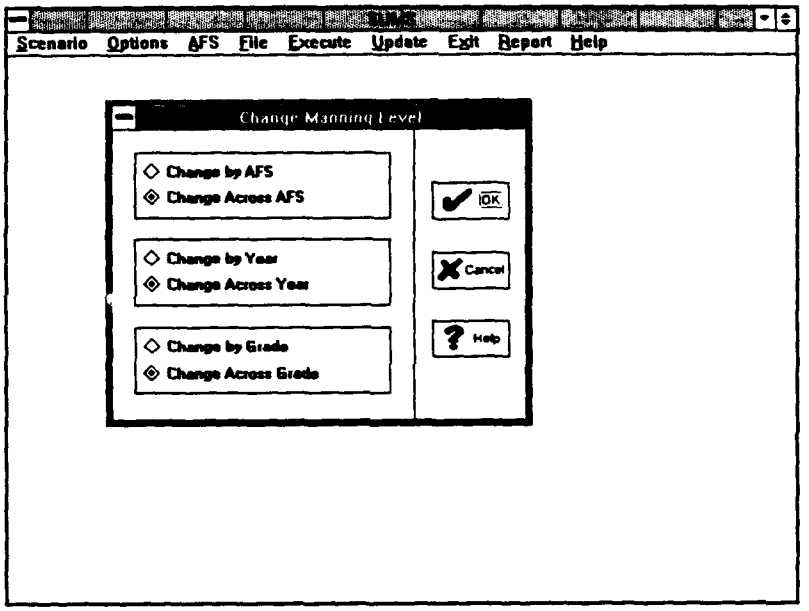

Figure 31. Manning Level Changes Parameters

each AFS/Cluster. For example, a 5% increase in the manning level for a particular AFS/Cluster will increase the maximum size of the inventory possible in that AFS/Cluster by 5%. Changes in manning levels may be specified by or across AFSs/Clusters, by or across years, and by or across grades. This gives the user eight possible options for changing the minimum manning levels:

- **Change By AFS, Change By Year, Change by Grade**
- **Change By AFS, Change By Year, Change Across Grade**
- **Change By AFS, Change Across Year, Change by Grade**
- **Change By AFS, Change Across Year, Change Across Grade**
- **Change Across AFS, Change By Year, Change by Grade**
- **Change Across AFS, Change By Year, Change Across Grade**
- **Change Across AFS, Change Across Year, Change by Grade**
- **Change Across AFS, Change Across Year, Change Across Grade**

By default, a 0.00% change in manning level changes is assumed for across projection years across all AFSs/Clusters. The specified percentage changes may reflect an increase or decrease in manning levels. An increase in inventories will be entered by the user as a positive percentage and a decrease will be entered as a negative (-) percentage.

Maximum Force-out Requirements

The **Maximum Force-out Requirements Screen**, shown in Figure 32, allows the user to specify the maximum proportion of a manning overage which will be forced-out, if force-outs are required to meet set manning levels by grade by AFS/Cluster or across AFSs/Clusters by projection year. Maximum force-out requirements may vary by AFS/Cluster or may be set

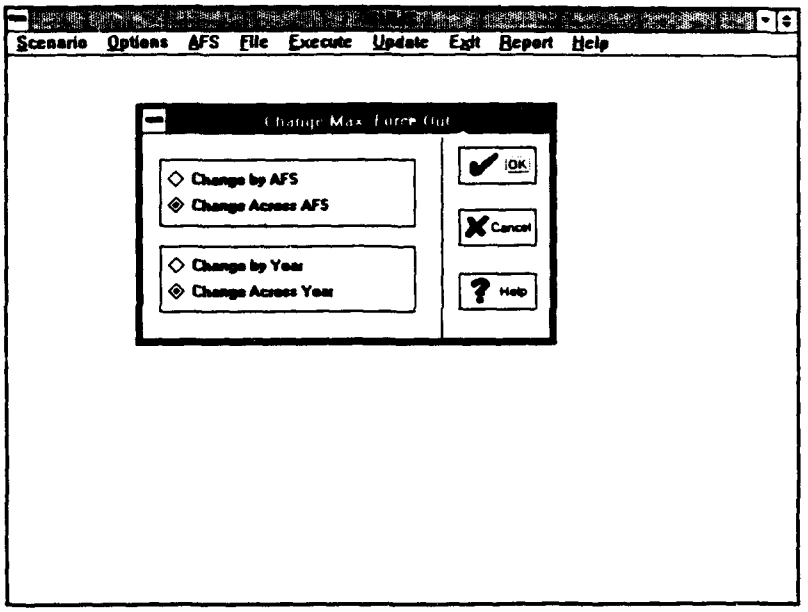

Figure 32. Maximum Force-Out Requirements Screen

across AFSs/Clusters. Force-out requirements may also vary by projection year or may be set across all projection years. This gives the user four possible options for changing the maximum force-out requirements:

- **Change By AFS, Change By Year**
- **Change By AFS, Change Across Year**
- **Change Across AFS, Change By Year**
- **Change Across AFS, Change Across Year**

By default, maximum force-out requirements are set at 100% across all projection years across all AFSs/Clusters. The percentage for force-out requirements must be a percentage which ranges between 0% and 100%.

Recruit Goal

The **Recruit Goal** option (Figure 33) allows the user to specify the minimum number of accessions for each year of the simulation. For each year of the simulation, the number of accessions will be at least equal to the specified recruit goal if this option is employed. If a smaller number of accessions than the recruit goal are needed to meet manning levels, this

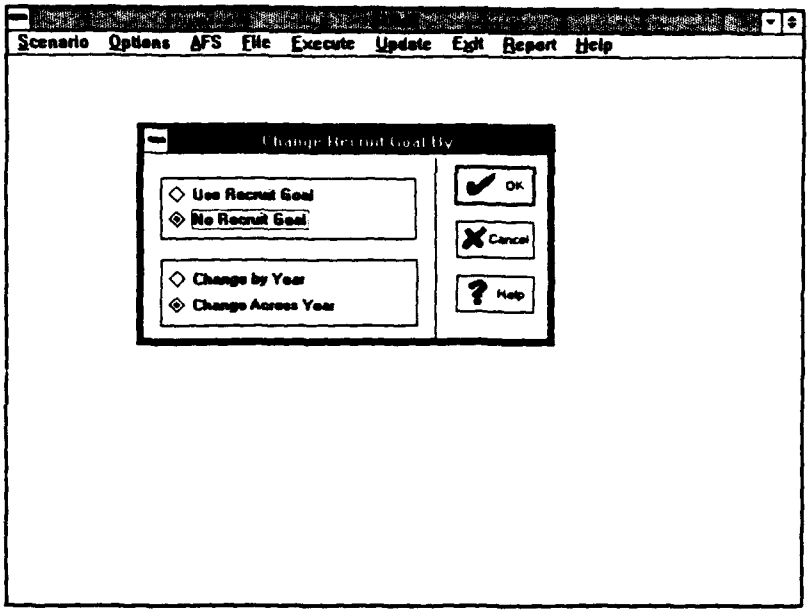

Figure 33. Recruit Goal Screen

option will force-out airmen in order to meet overall manning goals given the required number of accessions. The recruit goal may vary by projection year. The user may also specify the AFSs and grades from which to force-out airmen should force-outs be required in order to meet the recruit goal. If there are not sufficient airmen in the AFSs and grades specified for force-outs in order to meet force-out requirements for the recruit goal, the recruit goal will be met by "busting" endstrength. The required number of accessions for the recruit goal will be met, but the inventory for the force will be greater than the authorized manning levels.

The default value is to not employ this option. To employ the recruit goal, the user must select the **Use Recruit Goal** option (Figure 33). The user may then choose to specify recruit goals by or across years. If the recruit goal option is employed, the default value for the recruit goal is assumed to be 40,000 accessions for every projection year of the simulation.

After specifying the value of the recruit goal, the user may then specify the AFSs/Clusters and grades from which to force-out airmen should force-outs be required to meet the recruit goal. By default, force-outs will be taken from all AFSs/Clusters and all grades. The next screen to appear after specifying the value of the recruit goals will be the **Force-Outs to Achieve Recruit Goal Screen** shown in Figure 34. The user will have four options for specifying sources for force-outs:

- **By AFS, By Grade**
- **By AFS, Across Grade**
- **Across AFS, By Grade**
- **Across AFS, Across Grade**

The user may then specify the AFSs/Clusters and/or grades from which force-outs will be drawn if necessary to meet the recruit goal specified.

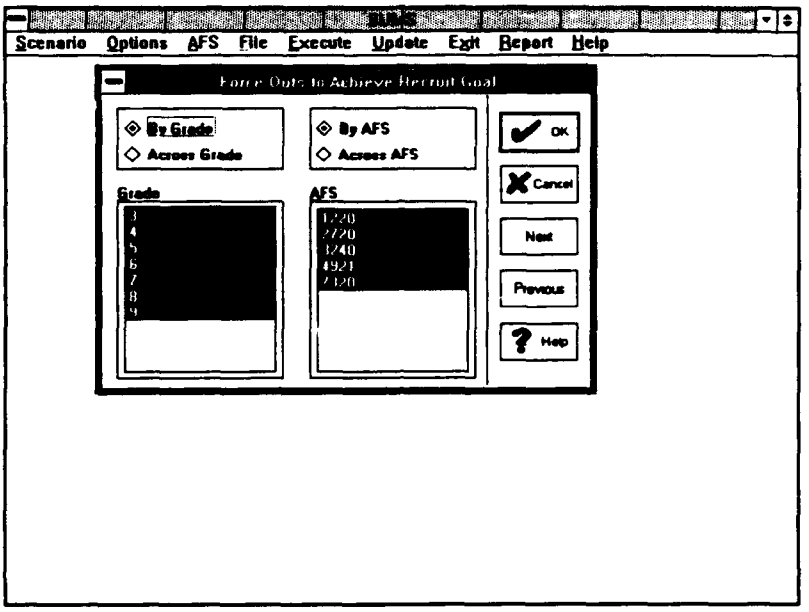

Figure 34. Force-Outs for Recruit Goal Screen

Reenlistment/Loss Model

The **Reenlistment/Loss Model** option (Figure 35) allows the user to alter the default continuation rates by AFS using reenlistment and eligibility rates. By default, this option is not employed in the simulation or optimization. The user must employ this option by selecting the **Use Reenlistment/Loss Model** option at the bottom of the screen. If the user employs this option, the AFSs included in the simulation or optimization will appear in the **AFS** box to the left of the screen. The user may select AFSs from this box to alter continuation rates for each AFS. When the user selects an AFS from the **AFS** box, the default values for the reenlistment and eligibility rates for first term, second term, and career airmen will appear. The user may revise any of these rates. These rates will then be used to determine new continuation rates for the selected AFSs/Clusters. These new continuation rates will then be used in the simulation or optimization. Default values for these rates were obtained from the Air Force Military Personnel Center (AFMPC) Retention Group.

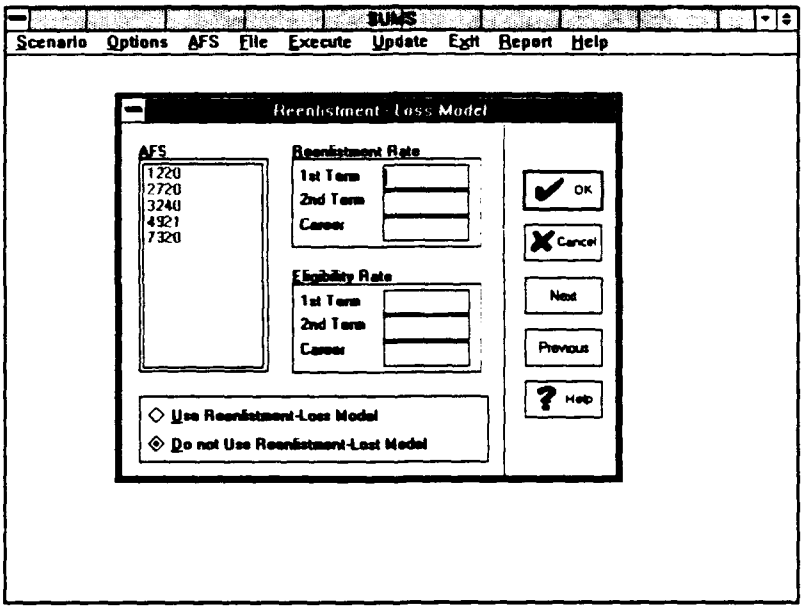

Figure 35. Reenlistment/Loss Screen

Productive Capacity

The **Productive Capacity** (Stone, et al, 1992a) option (Figure 36) allows the user to specify a parameter by which to shift the productive capacity function for a particular AFS/Cluster. This option gives the user the ability to specify a change in the productive capacity level of all airmen in an AFS/Cluster. For example, if the user wanted to assume that productive capacity in a particular AFS had increased by 10%, the user could use this option to specify a shift of 1.10 for that AFS. This would then increase the productive

capacity of all airmen and accessions in this AFS by 10% from its default productive capacity level. By default, this option is not employed in the simulation.

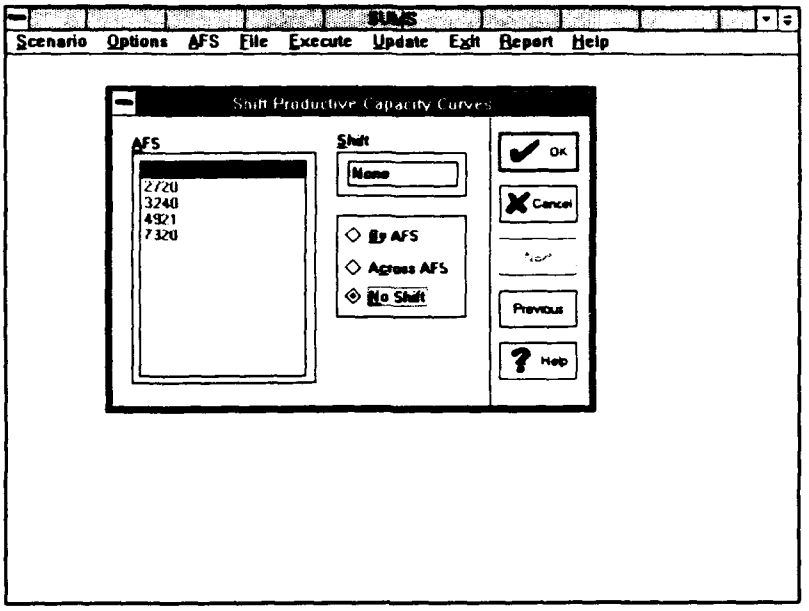

Figure 36. Productive Capacity Screen

The user may employ this option by selecting either **By AFS** or **Across AFS** at the screen shown in Figure 36. To specify shift parameters by AFS/Cluster, the user may select the desired AFS to change and enter the shift value in the box to the right. To specify a shift parameter across all AFSs/Clusters, the user would enter the value of the shift parameter in the box to the right. Increases in productive capacity may be represented by shift parameter values greater than 1, and decreases in productive capacity by shift parameter values less than 1. This parameter must be a number which ranges between 0 and 2. The default value for the shift parameter is one, or no change in productive capacity.

FILE

The **File Menu**, shown in Figure 37, allows the user to specify the name of the output file for the results of either a simulation or optimization or the name of the input parameter file to use for the next simulation.

By selecting the **Output File Name** option, the user may specify the new output file name without an extension (Figure 38). When the user executes the simulation or optimization, the output from the simulation or optimization will be directed to this files

using this name. Each table of output creates its own extension to the filename. These results may be viewed or printed using the **Report** option which will be discussed later.

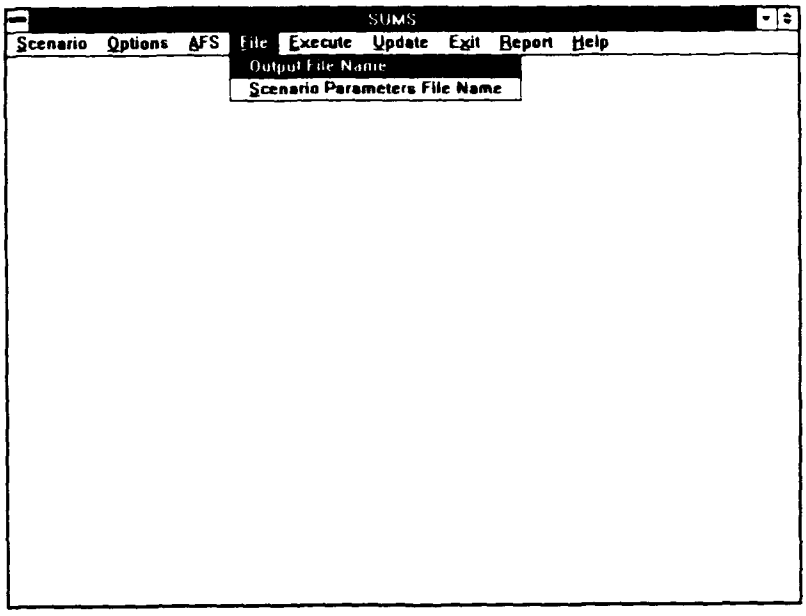

Figure 37. File Menu

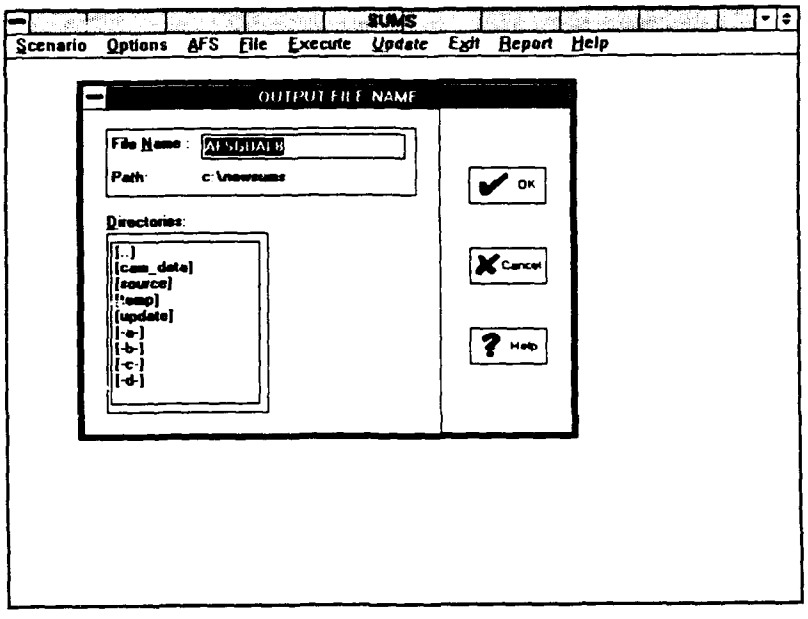

Figure 38. Output File Name Screen

By selecting the **Scenario Parameters File Name** option, the user may specify a filename with any extension desired to save all the parameters with their current values in all menu screens (Figure 39). This file will be saved for future use and may be recalled using the **Restore** option under the **Scenario, Select AFS/Cluster** option discussed earlier.

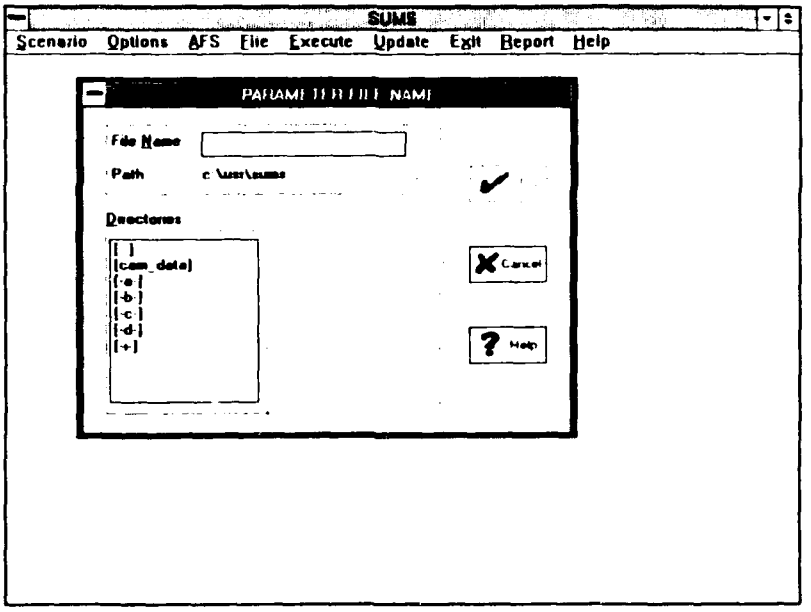

Figure 39. Scenario Parameters File Name

EXECUTE

The **Execute Menu**, shown in Figure 40, will allow the user to execute a simulation or to initiate the optimization algorithm in SUMS. If the user has specified on the **Output File Name Screen** the name of an output file which already exists (or uses the default output filename), the user will be prompted when selecting one of the options under this menu whether to overwrite the existing output file. The user must either consent to overwrite the existing output file or specify a new output file name before any of the simulation or optimization options under this menu will be executed. This menu allows the user three options:

- **Simulate and Retain Parameters**,
- **Simulate and Restart**,
- **Optimize**.

If the user selects the **Simulate and Retain Parameters** option, SUMS will execute the simulation and direct the output from that simulation to the output file specified under the **Output File Name** option. Once the simulation is complete, SUMS will return the user to

the **SUMS Main Menu Screen** (Figure 1). The population and all parameters and options will be those specified by the user before executing the simulation. The user once again has access to any of the menus in SUMS.

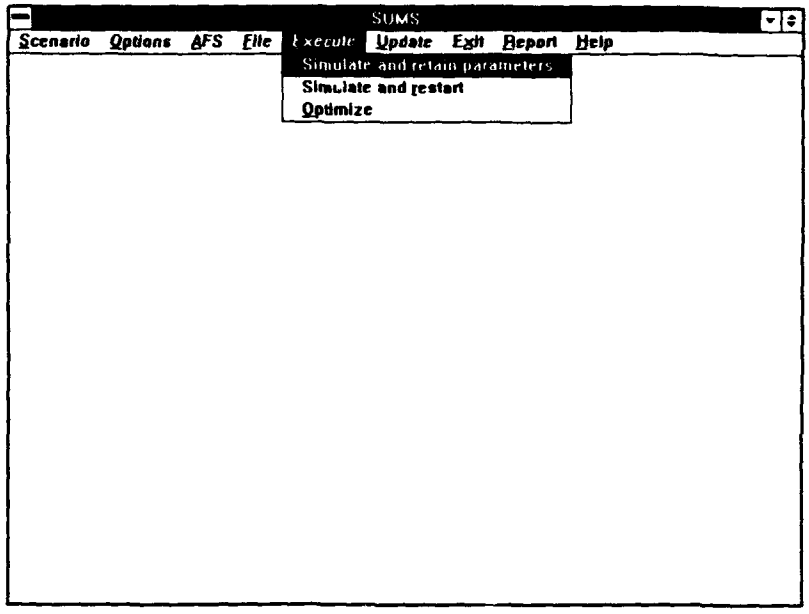

Figure 40. Execute Menu

If the user selects the **Simulate and Restart** option, SUMS will execute the simulation and direct the output from that simulation to the output file specified under the **Output File Name** option. Once the simulation is complete, SUMS will return the user to the **SUMS Menu Screen** shown in Figure 5. The population and parameter changes specified by the user will not be retained in SUMS if the user selects this option. The user must define a new population at the **Scenario Menu** shown in Figure 6.

If the user selects the **Optimize** option, SUMS will execute the optimization and direct the output from that optimization to the output file specified under the **Output File Name** option. Once the optimization is complete, SUMS will return the user to the **SUMS Main Menu Screen** (Figure 1). The population and all parameters and options will be those specified by the user before executing the optimization. The user once again has access to any of the menus in SUMS.

UPDATE

This menu, shown in Figure 41, will provide the user the ability to update and maintain the data contained within SUMS. The data contained within SUMS should be updated at the end of each fiscal year. The **Update** routine will require the user to provide

SUMS with several data files in specified formats. Each element in SUMS which may be updated will be discussed in detail in this section.

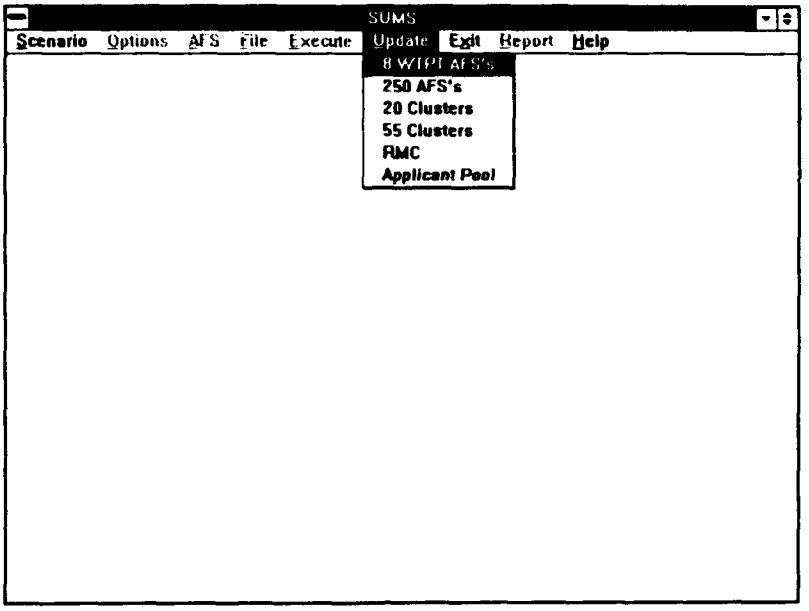

Figure 41. Update Menu

As shown in Figure 41, the user has the ability to update the data files for all populations in SUMS. Available populations to update include:

- **8 WTPT AFSs**
- **250 AFSs**
- **20 Clusters**
- **55 Clusters**.

The user need only provide one set a update data files as the same user provided files will be used to update all populations. Once the population to be updated has been specified, the user may then select the data elements to be updated. Figure 42 shows the elements from which the user may choose to update. The same elements may be updated for all of the populations. These elements include:

- **Continuation Rates**
- **Personnel Inventories**
- **Manning Requirements**
- **Training Costs**
- **Service State Values**
- **Selector AI**
- **Continuation Rate Across Grades**.

The files necessary for updating each of these elements will be discussed in this section. Providing the required data files in their specified format is essential for successfully updating the data contained in SUMS using the **Update** routine.

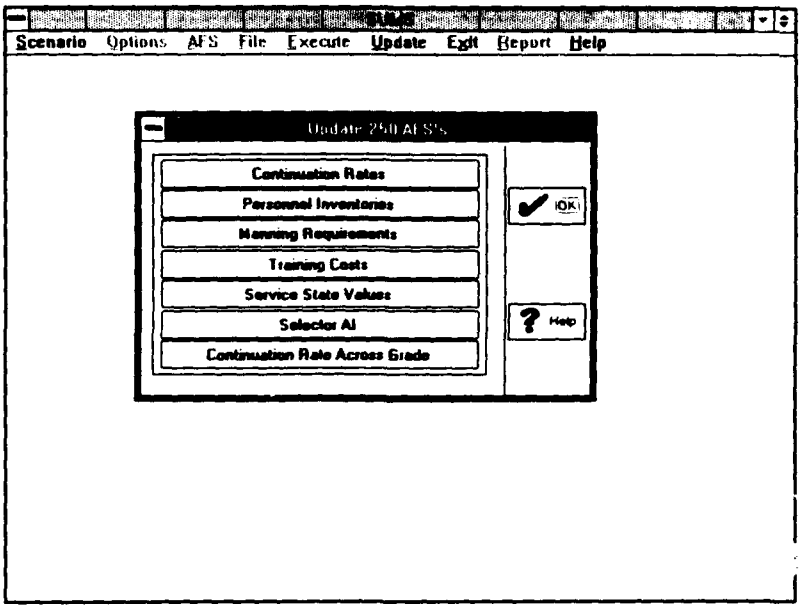

Figure 42. Update 250 AFSs Screen

Figure 41 also contains two specific data elements which may be updated from this menu. These two elements are separate from the other segment of the **Update** routine because these two elements are used for every population within SUMS. The two elements which may be updated from this menu are:

- **RMC**
- **Applicant Pool.**

The procedure and necessary files for updating these elements is also discussed in this section.

Continuation Rates

To update the continuation rates within SUMS for any population, the user must provide SUMS with two input files. Both files will have the same exact format. The files will be obtained from the Uniform Airman Records (UARs) in the Historical Airman Data (HAD) base. The two files will be "snapshots" of the UAR taken 12 months apart. For example, one file could be a "snapshot" of the UARs for June of 1990 and the second a "snapshot" of the UARs for June of 1991. These files will be used to determine the probability of individual airmen continuing from one YOS to another.

The two UAR "snapshot" files must be provided in the format below:

Field	NC	SC	EC	Name	Description
1	9	1	9	SSAN	SSAN
2	4	10	13	TAFMS	TAFMS date (YYMM)
3	5	14	18	CAFSC	Control AFSC
4	2	19	20	GRADE	Grade
5	1	21	21	QG	AFQT group
6	2	22	23	AFQT	AFQT score
7	2	24	25	MS	ASVAB score -- Mechanical
8	2	26	27	AS	ASVAB score -- Administrative
9	2	28	29	GS	ASVAB score -- General
10	2	30	31	ES	ASVAB score -- Electronic
11	5	32	36	PAFSC	Primary AFSC

The **Update** routine will prompt the user for the "Start Date" and the "End Date." The "Start Date" is the date of the earliest snapshot; for example, June of 1990 would be entered as 90 06. The "End Date" is the date of the latest snapshot. The **Update** routine will also prompt the user for the names of the two UAR "snapshot" files. Once this information is specified, the **Update** routine will update the specified population in SUMS using the new data files.

Personnel Inventories

To update the personnel inventories within SUMS for any population, the user must provide SUMS with one input file. The file will be obtained from the UAR and will also be a "snapshot" at a given time. This file will be used to determine the experience and aptitude distribution of airmen in the force.

The UAR "snapshot" file must be provided in the format below:

Field	NC	SC	EC	Name	Description
1	6	1	6	SSAN	SSAN
2	6	7	12	TAFMS	TAFMS date (YYMM)
3	1	13	13	CAFSC	Control AFSC
4	2	14	15	GRADE	Grade
5	2	16	17	QG	AFQT group
6	2	18	19	AFQT	AFQT score
7	2	20	21	MS	ASVAB score -- Mechanical
8	1	22	22	AS	ASVAB score -- Administrative
9	2	23	24	GS	ASVAB score -- General
10	2	25	26	ES	ASVAB score -- Electronic
11	4	27	30	PAFSC	Primary AFSC

The **Update** routine will prompt the user for the name of the UAR "snapshot" file. Once this information is specified, the **Update** routine will update the specified population in SUMS using the new data files.

Manning Requirements

To update the manning requirements within SUMS for any population, the user must provide SUMS with an input file of the requirements. The manning requirements file should contain manning authorizations obtained from the Air Force Manpower and Personnel Center (AFMPC) by grade for each AFS or Cluster included in SUMS. Manning authorizations for Clusters calculated by summing manning authorizations for all AFSs included in each Cluster (see Appendix C for AFSs included in each Cluster).

The manning requirements file must be provided in the format below:

AFS
Grade manning authorization

Each field should be separated by a blank. Manning authorizations for grades **3** through **9** will be specified below each AFS (or Cluster name). Manning authorizations for grades **1** and **2** should be added to grade **3** authorizations. Names for Clusters should be specified as for example: **0001** for Cluster 1 of 20 Clusters or Cluster 1 of 55 Clusters. A sample portion of a personnel inventory file is shown below:

```
1220
3    702
4    566
5    609
6    322
7    221
8    122
9    47
3240
3    802
4    546
5    509
6    422
7    121
8    23
9    11
```

The **Update** routine will prompt the user for the name of the personnel inventory file to be used for the update. Once the file name has been specified, SUMS will update the manning requirements for the specified population.

Training Costs

Training costs within SUMS may be updated through the **Update** routine by specifying a factor obtained from the latest Cost Factors Manual by which to increase the costs. To update training costs, the user may specify the factors by which to increase the costs in the screen shown in Figure 43. Training costs will then be increased in the data files for SUMS (for the population specified) by the relative factor specified.

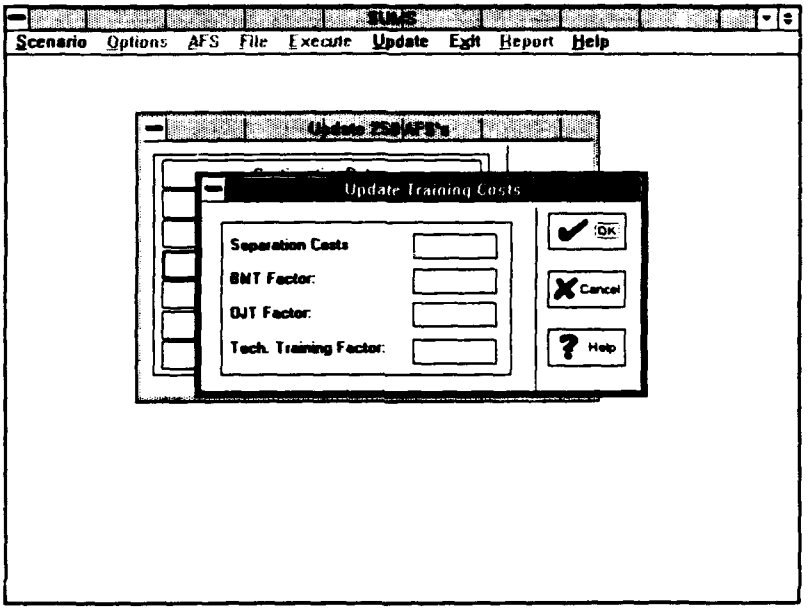

Figure 43. Update Training Costs Screen

Service State Values

Service state values within SUMS may be updated through the **Update** routine by specifying a factor by which to increase the values. Service state values represent the opportunity cost to the airman of remaining in the service (Stone et al., 1989), based on civilian earnings surveys administered monthly by the Bureau of the Census (U.S. Department of Commerce, 1986). To update the service state values, the user may specify the factor by which to increase the values in the screen shown in Figure 44. Service state values will then be increased in the data files for SUMS (for the specified population) by the relative factor specified.

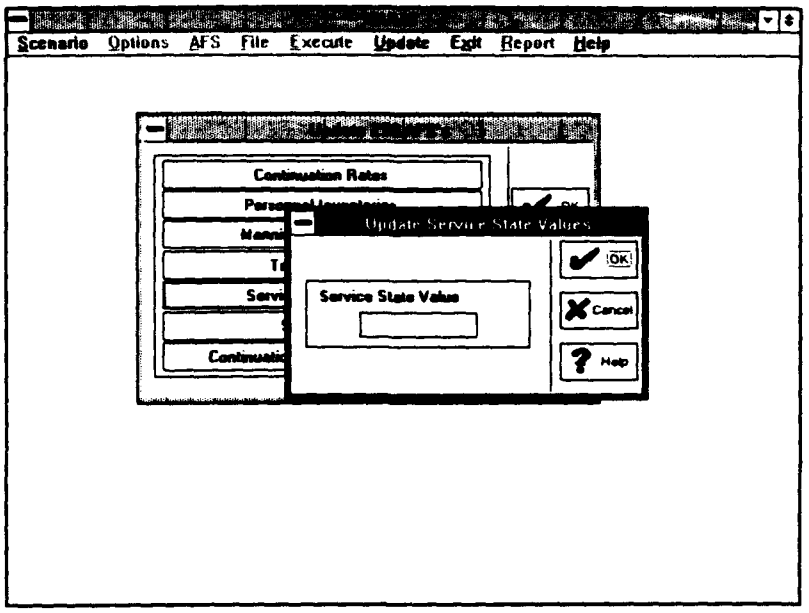

Figure 44. Update Service State Values Screen

Selector AI

Selector AIs and minimum scores for selector AIs for AFSs and Clusters within SUMS may be updated using the **Update** routine. The user must provide a file containing the AFSs or Clusters to be updated and the Selector AI and *minimum score*. Appendix A provides the selector AI and minimum score established for each Cluster within SUMS.

The selector AI file must be provided in the format below:

AFS (or Cluster) Selector AI Minimum Score

Each field should be separated by a blank. Names for Clusters should be specified as for example: **0001** for Cluster 1 of 20 Clusters or Cluster 1 of 55 Clusters. The **Update** routine will prompt the user for the name of the selector AI to be used for the update. Once the file name has been specified, SUMS will update the selector AIs for the specified population.

Continuation Rate Across Grades

To update the continuation rates across grades within SUMS for any population, the user must provide SUMS with two input files. Both files will have the same exact format. The files will be obtained from the Uniform Airman Records (UARs). The two files will be "snapshots" of the UAR taken 12 months apart. For example, one file could be a

"snapshot" of the UARs for June of 1990 and the second a "snapshot" of the UARs for June of 1991. These files will be used to determine the probability of individual airmen continuing from one YOS to another. These are also the same files necessary to update **Continuation Rates**.

The two UAR "snapshot" files must be provided in the format below:

Field	NC	SC	EC	Name	Description
1	9	1	9	SSAN	SSAN
2	4	10	13	TAFMS	TAFMS date (YYMM)
3	5	14	18	CAFSC	Control AFSC
4	2	19	20	GRADE	Grade
5	1	21	21	QG	AFQT group
6	2	22	23	AFQT	AFQT score
7	2	24	25	MS	ASVAB score -- Mechanical
8	2	26	27	AS	ASVAB score -- Administrative
9	2	28	29	GS	ASVAB score -- General
10	2	30	31	ES	ASVAB score -- Electronic
11	5	32	36	PAFSC	Primary AFSC

The **Update** routine will prompt the user for the "Start Date" and the "End Date." The "Start Date" is the date of the earliest snapshot; for example, June of 1990 would be entered as 90 06. The "End Date" is the date of the latest snapshot. The **Update** routine will also prompt the user for the names of the two UAR "snapshot" files. Once this information is specified, the **Update** routine will update the specified population in SUMS using the new data files.

Regular Military Compensation (RMC)

The values for RMC may also be updated using the **Update** routine from SUMS. To update RMC the user must select the **RMC** option from the **Update Menu** shown in Figure 41. This will update the RMC values for all populations in SUMS. The user must provided SUMS with three files: one containing basic pay, a second containing basic allowance for quarters (BAQ), and a third containing basic allowance for subsistence (BAS). The **Update** routine will use these three files to update the RMC values within SUMS.

The first file must be named **BASIC.NEW**. The format for the basic pay file must be as follows:

Field	Description
1	GRADE (Values 3 - 9)
2	Monthly pay for YOS < 2
3	Monthly pay for YOS = 2

4	Monthly pay for YOS = 3
5	Monthly pay for YOS = 4
6	Monthly pay for YOS = 6
7	Monthly pay for YOS = 8
8	Monthly pay for YOS = 10
9	Monthly pay for YOS = 12
10	Monthly pay for YOS = 14
11	Monthly pay for YOS = 16
12	Monthly pay for YOS = 18
13	Monthly pay for YOS = 20
14	Monthly pay for YOS = 22
15	Monthly pay for YOS = 26

Monthly pay values must be provided in this file for grades 3 through 9. Each field must be separated by a blank.

The second file must be named **BAQ.NEW**. The format for the BAQ file must be as follows:

Field	Description
1	GRADE (Values 3 - 9)
2	Monthly BAQ for Single
3	Monthly BAQ for Married with 2 dependents

Monthly BAQ values must be provided in this file for grades 3 through 9. Each field must be separated by a blank.

The third file must be named **BAS.NEW**. The BAS file will contain only one number, the value for monthly BAS pay.

Applicant Pool

To update the applicant pool in SUMS the user must select the **Applicant Pool** option from the **Update Menu** shown in Figure 41. This will update the applicant pool used for all populations in SUMS. To update the applicant pool within SUMS, the user must provide the file containing the new applicant pool. The file will be obtained from the Military Entrance Processing Station (MEPS) application records. The file should contain all Air Force applicants with MEPS records for a given year, for example, FY90. Duplicate applicant records should be excluded from this file. This file will then be used to determine aptitude distribution of future applicants in SUMS.

The MEPS applicant file must be named **MEPS.DAT**. The format of the **MEPS.DAT** must be as provided below:

Field	NC	SC	EC	Name	Description
1	4	1	4	DOA	Date - Action
2	2	5	6	AFQT	AFQT Score
3	2	7	8	MECH	Mechanical Score
4	2	9	10	ADM	Administrative Score
5	2	11	12	GEN	General Score
6	2	13	14	ELEC	Electronic Score
7	2	15	16	SS1	Standardized subtest score - gs
8	2	17	18	SS2	Standardized subtest score - ar
9	2	19	20	SS3	Standardized subtest score - wk
10	2	21	22	SS4	Standardized subtest score - pc
11	2	23	24	SS5	Standardized subtest score - no
12	2	25	26	SS6	Standardized subtest score - cs
13	2	27	28	SS7	Standardized subtest score - as
14	2	29	30	SS8	Standardized subtest score - mk
15	2	31	32	SS9	Standardized subtest score - mc
16	2	33	24	SS10	Standardized subtest score - ei
17	2	35	36	SS11	Standardized subtest score - ve

The **Update** routine will prompt the user for the name of the MEPS applicants file. Once this information is specified, the **Update** routine will update the applicant pool used in SUMS.

EXIT

The **Exit Menu**, shown in Figure 45, allows the user to end the session and exit SUMS to Windows by selecting the **End Session** option. The user also has the ability to select the **Restart** option under this menu. If the user selects the **Restart** option, the user may then specify a new population for SUMS. All parameters will return to their default values when the **Restart** option is employed.

REPORT

The **Report Menu**, shown in Figure 46, allows the user to view and print the output of an executed simulation or optimization. The file to be viewed or printed will be the file specified on the **Output File Name Screen** (Figure 38). Output from a previously executed scenario can be viewed or printed by specifying the name of the output file specified when the simulation or optimization was executed.

Output from an executed simulation is contained in eight different tables. The user may select the **View Simulation Results** option to view output or the **Print Simulation Results** option to print output. The user may only select only one table at a time to view

from the **Select Simulation Table to View Screen** in Figure 47. The user may select as many tables as desired at one time to print from the **Select Simulation Table to Print Screen** in Figure 48. Tables available for viewing or printing include:

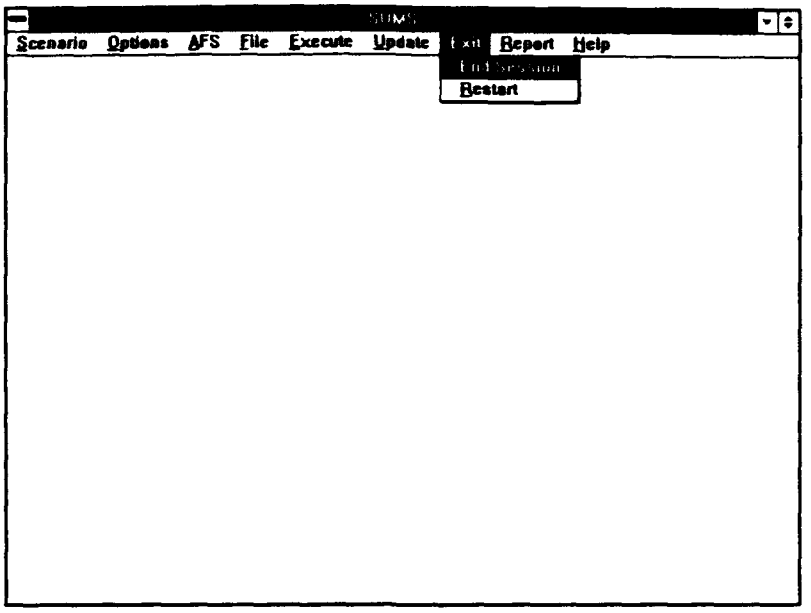

Figure 45. Exit Menu

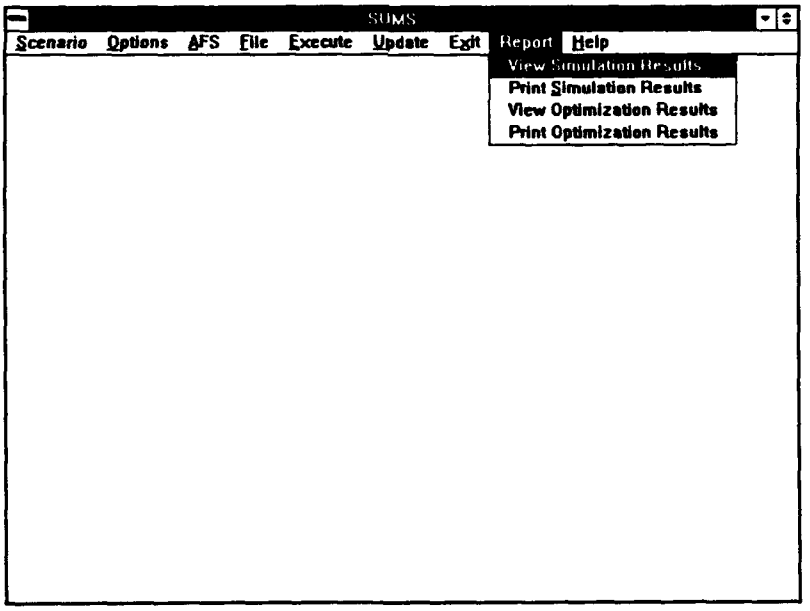

Figure 46. Report Menu

- **Allocation Criteria,**
- **AFS Inventory,**
- **Average Productive Capacity,**
- **Accession Breakout,**
- **Summary Accession Breakout,**
- **Scenario Summary,**
- **Scenario Parameters,**
- **Across AFS Scenario Summary,**
- **YOS Distribution By AFS,** and
- **YOS Distribution Across AFS.**

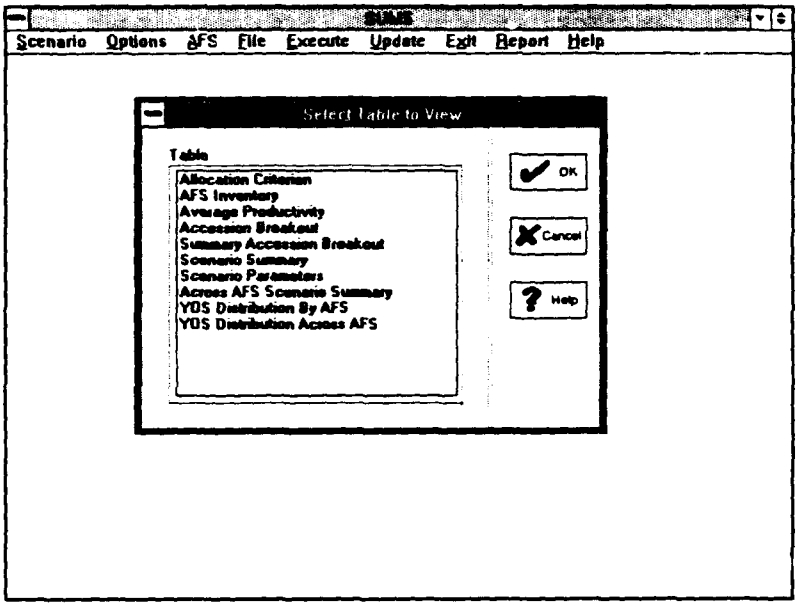

Figure 47. Select Simulation Table to View

The **Allocation Criterion Table** displays the costs, values or productive capacity values used in determining the allocation of accessions. These criterion will be shown by aptitude group by AFS/Cluster for each year of the simulation.

The **AFS Inventory Table** contains information on the inventory of each AFS/Cluster of the simulation. The Inventory table contains information regarding manning goals, initial inventory, separations, retirements, accessions, promotions, force-outs, overages (shortages), ending inventory, and average productive capacity. An Inventory table is reported for every AFS/Cluster for every projection year of the simulation.

The **Average Productive Capacity Table** displays the average productive capacity by YOS for each AFS and across AFSs for each year of the simulation. The **Accession Breakout Table** displays the number of accessions by aptitude group for each AFS/Cluster

in each projection year of the simulation. The **Summary Accession Breakout Table** displays the number of accessions by aptitude group for each year of the simulation.

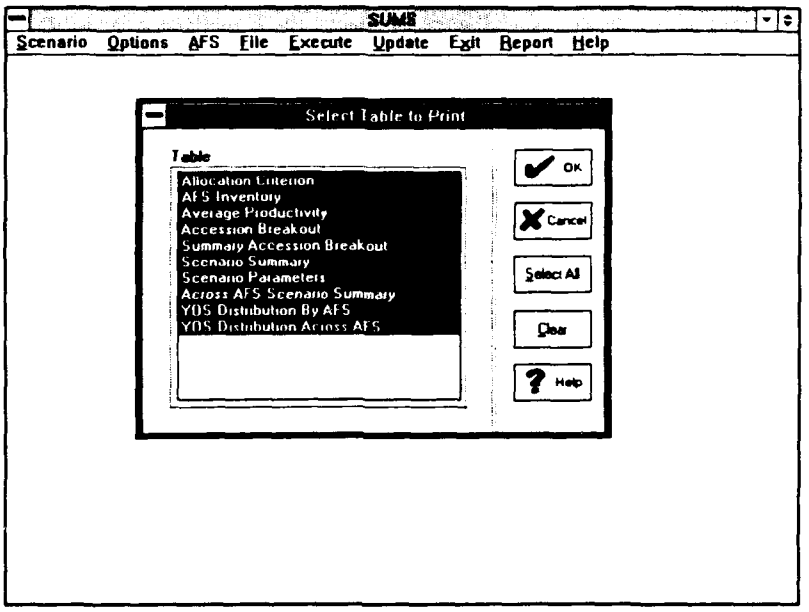

Figure 48. Select Simulation Table to Print

The **Scenario Summary Table** contains summary statistics across AFSs/Clusters for each projection year of the simulation. Summary statistics are provided for the number of accessions, total net return across all AFSs, total average productive capacity across all AFSs, total population across all AFSs, total cost and total value across all AFSs, and net utility across all AFSs.

The **Scenario Parameters Table** details the parameters used in the simulation. This file will include the values used for each parameter or option employed in the scenario. For example, AFSs/Clusters included in the simulation, number of projection years, applicant pool size, promotion and accession methodologies and policies employed, and any changes to costs/values, manning requirements or goals, Selector AIs or productive capacity.

The **Across AFS Scenario Summary Table** provides the same information as the **AFS Inventory Table** across all AFSs/Clusters in the simulation for each projection year. This table includes manning goals, initial inventories, separations, retirements, accessions, promotions, force-outs, overages (shortages), and ending inventories summed across all AFSs/Clusters included in the scenario for each year of the simulation. Average productive capacity across all AFSs/Clusters is also included in the table.

The **YOS Distribution by AFS Table** contains the distribution of the force by year of service (YOS) for each projection year by AFS. The **YOS Distribution Across AFS Table** provides the YOS distribution for the force across AFSs by projection year.

Output from an executed optimization is contained in two different tables. The user may select the **View Optimization Results** option to view output or the **Print Optimization Results** option to print output. The user may only select only one table at a time to view from the **Select Optimization Table to View Screen** in Figure 49. The user may select as many tables as desired at one time to print from the **Select Optimization Table to Print Screen** in Figure 50. Tables available for viewing or printing include:

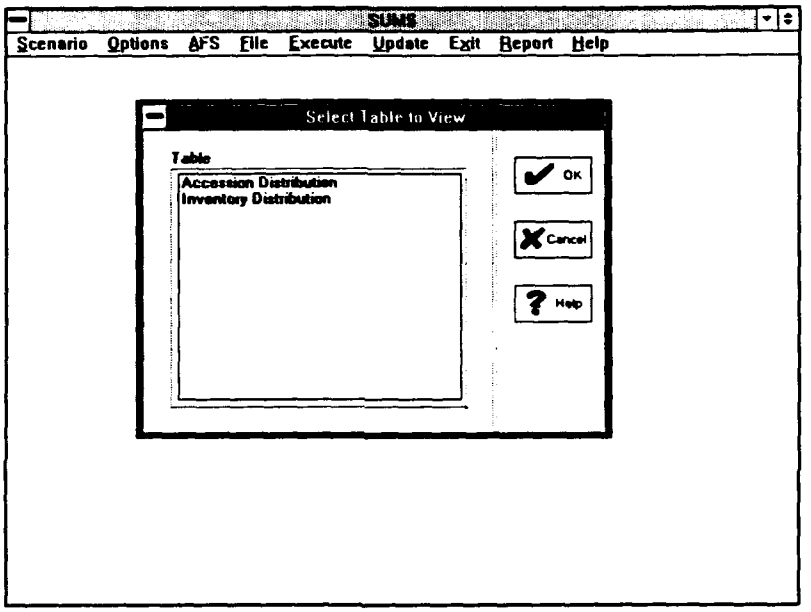

Figure 49. Select Optimization Table to View

The **Accession Distribution Table** provides the optimal distribution of accessions by aptitude by AFS/Cluster which either minimizes or maximizes the use specified objective function of the optimization (see Appendix B). This distribution is based upon the parameters of the optimization model including the aptitude distribution of the applicant pool, the user specified manning levels and the user specified continuation rates.

The **Inventory Distribution Table** provides the experience distribution of the force in the steady-state given the optimal allocation of accessions by aptitude by AFS/Cluster. This experience distribution is determined by minimizing or maximizing the selected objective function (see Appendix B) given the aptitude distribution of the applicant pool, the user specified manning levels and the user specified continuation rates.

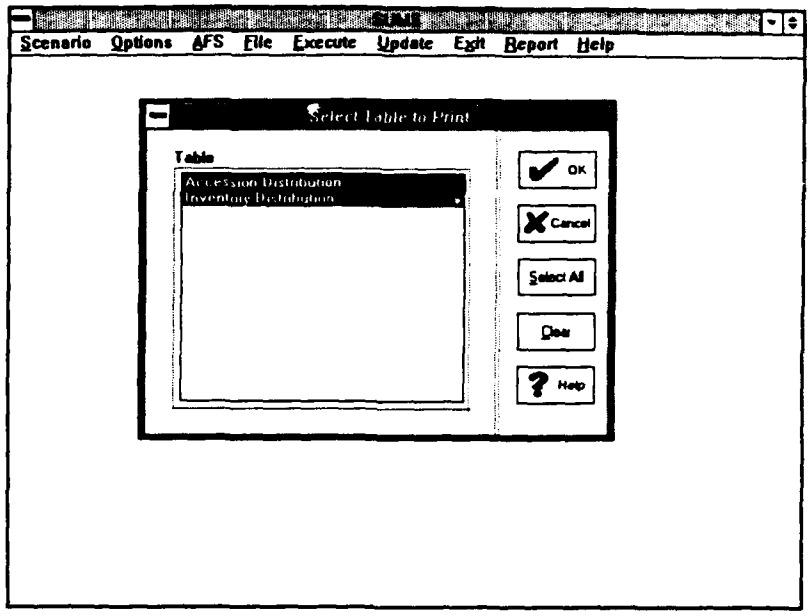

Figure 50. Select Optimization Table to Print

HELP

This menu, shown in Figure 51, will provide the user with information concerning each screen in SUMS, as well as information about operating within Windows. From any screen within SUMS, the user may select the **HELP** menu in order to obtain information on using the screen or option and information concerning the origin of default values for the option.

CONCLUSIONS

SUMS is a simulation package which provides personnel managers and policy makers with a tool to analyze the effects of manpower and personnel decisions and policies on specific enlisted career fields and overall force structure. Force level analysis can be performed at three levels: 250+ Air Force specialties (AFSs) at the 5-digit level and individual AFSs clustered into 20 groups and 55 groups to simulate a force level environment. Given an initial force structure, continuation rates, inventories, personnel training and maintenance costs, and an applicant pool, SUMS can simulate the implementation of a policy decision and evaluate the resulting changes on overall force productive capacity, costs, value, and inventory levels. SUMS also provides summary information by AFS or across AFSs concerning end-strength, accessions by aptitude, promotions, separations, retirements, force-outs, and overages/shortages for each year of the

simulated time period. SUMS can analyze force structures in terms of grade, aptitude, and experience within and across AFSs.

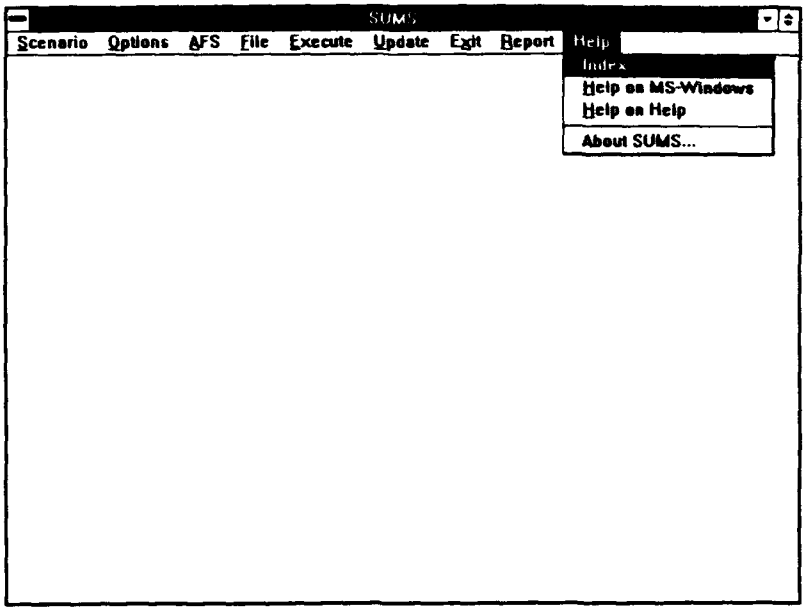

Figure 51. Help Menu

FUTURE RESEARCH

The Air Force retrains a significant number of enlisted personnel each year to better manage the force and its AFSs. SUMS should be extended to include the flows of personnel across AFSs caused by retraining. SUMS presently includes only entry level AFSs. The extension to retraining would also allow inclusion of AFSs that require a skill level attainment for entry, superintendent and manager level AFSs, and special identifier career fields (such as recruiters). This enhancement would improve the ability of SUMS users to analyze the effects of retraining with respect to maintaining experienced personnel, minimizing retraining costs, and improving overall force level retention. The implementation of retraining in SUMS would require the design and development of a retraining allocation algorithm which would allow the user to select among several objectives such as productive capacity, cost, value, etc., to determine the best allocation of potential retrainees among available AFSs. The AFSs into which personnel may retrain can be restricted using the minimum required selector aptitude index (AI) score for that AFS. This assumption could be ignored, allowing the algorithm to actually determine the minimum selector AI score for each AFS for retraining which would maximize or minimize the designated objective. The user would have the ability to restrict retraining alternatives (establish retraining paths which could not be used) and to analyze the tradeoffs between cost, productive capacity, or value associated with these restrictions.

Other literature tends to suggest that the recruitment cost associated with attracting enlisted personnel increases as the aptitude of the recruit increases. The Army indicates

that an increase in recruiting costs is incurred for recruiting high mental aptitude/high school graduates over lower aptitude recruits (Armor, Fernandez, Bers, and Schwarzbach, 1982). A study of recruiting costs should be performed to determine if such differentials exist for the Air Force. SUMS would then be modified to allow for differential recruiting costs by aptitude. The user would have the option of specifying his/her own differential recruiting costs or using the differential recruiting costs identified in this study. These differential recruiting costs could be included as a part of the objective function used in the accession allocation algorithm of SUMS. SUMS would thus allow the user to analyze the effects of recruiting higher quality personnel on cost, value, productive capacity, and retention.

The Air Force has been using the lump-sum special separation benefit (SSB) and the voluntary separation incentive (VSI) as incentives to induce personnel to voluntarily separate from the service. If these voluntary programs do not attain their separation goals, the Air Force will implement involuntary programs in order to attain force level requirements. SUMS can be modified to provide the costs of implementing separation programs, as well as analyzing the short-term and long-term implications of the force drawdown on the experience and aptitude mix of the force.

SUMS is presently only able to use one classification factor, or selector AI, for each AFS. Several AFSs have two selector AIs. SUMS could be extended to allow allocation of recruits to AFSs based on more than one selector AI. Multiple selector AI's would affect the optimal allocation of recruits, future experience and aptitude mix, training costs, and retention. SUMS would provide the user with the ability to analyze various selector AI specifications by AFS and their affect on the AFS, as well as the total force.

As indicated in the retraining option, a number of 5-digit career fields are not comprised of entry level personnel (E3's or E3's through E7's). Some AFSs require a grade of E4 before the airman can enter, while others are management AFSs for several other AFSs. SUMS presently includes superintendent or chief enlisted manager levels in only one of the AFSs which are supervised by the superintendents or managers. Thus, some AFSs under the supervisory AFS will have no manning levels at the upper grade levels such as E8 and E9. SUMS could, however, be extended to include non-entry level AFSs with the inclusion of retraining. AFSs requiring a specific grade or skill level requirement for entry could be included in SUMS by allowing personnel from eligible AFSs and meeting minimum experience requirements to be retrained into the non-entry level AFSs. This would also then allow manning levels at the superintendent or chief enlisted manager to be met through promotees from eligible AFSs being promoted (retrained) into the management fields. This could also allow the inclusion of special identifiers such as recruiters. Mappings or promotion paths would be specified when identifiable. A random allocation scheme could be used for those AFSs who do not exhibit consistent promotion or transfer paths.

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APPENDIX A

Allocation Methodologies

This appendix details the methodology used to estimate the quantitative factors which affect the allocation of enlisted personnel. SUMS allocates accessions to AFSs/Clusters in order to fill AFS/Cluster-specific manning vacancies caused by the attrition/promotion process and manning requirements. SUMS selects recruits from a given accession pool comprised of a given aptitude mix based on the four ASVAB composite scores (Mechanical, Administrative, General, and Electronic). The allocation of aptitude-specific accessions to AFSs/Clusters is performed using a methodology which maximizes or minimizes the total benefit resulting from an allocation of aptitude-specific accessions to multiple AFSs/Clusters. The user has been provided eight alternative methodologies for allocating accessions:

(1) Random Arrival,
(2) Maximize Expected Total Net Return,
(3) Maximize Total Productive Capacity,
(4) Maximize Total Value,
(5) Minimize Total Cost,
(6) Maximize Expected Total Productive Capacity,
(7) Maximize Expected Total Value, and
(8) Minimize Expected Total Cost.

Random Arrival

Random arrival, represents a slightly different methodology for the allocation of aptitude-specific accessions from the other allocation alternatives. Random arrival uses a purely random procedure for determining the order in which aptitude-specific applicants from the applicant pool become available as possible accessions. Each applicant is randomly selected from the applicant pool with a given aptitude distribution. This method attempts to mirror the aptitude distribution of applicants which recruiters actually confront at Military Entrance Processing Station (MEPS). The Random Arrival allocation of each accession is performed without regard to the aptitude distribution of future applicants. Accessions are allocated to AFSs/Clusters as they randomly arrive at the MEPS on the basis of relative need by each AFS/Cluster. For example, if AFS_i needs two times as many accessions as AFS_j and the applicants that enter the MEPS are equally qualified for both AFS_i and AFS_j, then those available accessions will be allocated to AFS_i at a rate of 2 for 1 relative to AFS_j accessions. Thus, qualified applicants are randomly allocated to AFSs/Clusters based on the relative needs of the AFSs/Clusters. This method does not maximize or minimize total system welfare based on benefits, costs, or any other allocation criterion.

Alternative Methodologies

The other seven allocation alternatives use the same methodology differing only in terms of the allocation criterion employed to determine to which AFS/Cluster each accession will be allocated. Each of the alternatives (2) through (8) uses a different allocation criterion. The allocation criterion represents the single quantitative factor assignable to each aptitude group which is used to determine the "best" AFS/Cluster allocation of the recruits. Aptitude groups are based on the range of possible scores for the selector aptitude index (AI) of each AFS/Cluster. For example, an AFS/Cluster with a minimum selector AI of M-60 would consist of four aptitude groups comprised of applicants with M scores of 99 to 90, 89 to 80, 79 to 70, and 69 to 60. "Best" in this context refers to the allocation of a single accession to a specific AFS/Cluster making the greatest contribution to the overall welfare of the system as defined by the objective to be maximized or minimized. The objective is expressed in terms of one of seven allocation criterion: expected total net return, total productive capacity, total value, total cost, expected total productive capacity, expected total value, or expected total cost.

To determine the allocation of accessions across AFSs/Clusters for these seven alternatives, a linear programming routine (Seplo, Deo, & Kowalik, 1983)[1] is used. This linear programming algorithm determines the number of qualified applicants from each aptitude group to be assigned to each AFS/Cluster across all AFSs/Clusters specified in the system. The allocation solution is obtained by maximizing (minimizing):

$$\sum_{k=1}^{K}\sum_{x=1}^{M}(V_{x,k}\times n_{x,k}) \qquad \text{(A-1)}$$

subject to the constraints:

$$\sum_{k=1}^{K} n_{x,k} \le a_x \quad \text{for all } \mathbf{x} \qquad \text{(A-2)}$$

$$\sum_{x=1}^{M} n_{x,k} \le r_k \quad \text{for all } \mathbf{k} \qquad \text{(A-3)}$$

$$n_{x,k} \ge 0 \quad \text{for all } \mathbf{x} \text{ and } \mathbf{k} \qquad \text{(A-4)}$$

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[1] Seplo, M.M., Deo, N. & Kowalik, J.S. (1983). *Discrete optimization algorithms with Pascal programs.* Englewood Cliffs: Prentice-Hall.

where,

K is the number of AFSs/Clusters,
M is the number of aptitude groups,
$V_{x,k}$ is the allocation criterion value to be accrued to the system from allocating an accession with aptitude **x** to AFS/Cluster **k**,
x is the aptitude group,
k is the kth AFS/Cluster,
$n_{x,k}$ is the number of accessions with aptitude **x** assigned to AFS/Cluster **k**,
a_x is the number of accessions of aptitude **x**, and
r_k is the accession requirement for AFS/Cluster **k** which is necessary to meet the desired manning level.

The objective function (Equation A-1) is the total allocation criterion value of all accessions assigned to all AFSs/Clusters from all aptitude groups. The allocation problem is solved by finding the maximum (minimum) value for this function. If cost were selected as the allocation criterion, the objective function would be minimized versus the selection of productivity as the allocation criterion which would be maximized. Equation A-2 constrains the number of accessions assigned from an aptitude group to the number of accessions available in the group. Equation A-3 constrains the number of accessions assigned to an AFS/Cluster to be less than or equal to the established manning level for that AFS/Cluster. This constraint does not affect the allocation of accessions while the number of accessions allocated to an AFS/Cluster is below the established manning level for that AFS/Cluster. Equation A-4 specifies that a negative number of accessions with aptitude **x** cannot be assigned to any AFS/Cluster.

Expected Total Net Return

The allocation criterion expected total net return, encompasses several important factors: productive capacity, value of services produced by personnel in the Air Force, probability of attrition, training costs, recruitment costs, and personnel maintenance costs (regular military compensation). These factors are combined into a single measure called expected net return for any aptitude cohort in any AFS/Cluster. The expected net return for an individual with aptitude **x** is defined simply as the difference between expected value and expected cost over the specified horizon, **T**. Thus, the objective function to be maximized is the summation of expected net return across all accessions allocated to all AFSs/Clusters.

To allocate accessions to the AFSs, a measure of expected net return, $\mathbf{ETNR}_{x,k}$, is required for the **k**th AFS/Cluster. This value is estimated in three steps: estimation of expected value, estimation of expected costs, and estimation of expected net return.

Estimation of Expected Value

The expected value for an individual with aptitude x equals the summation over the specified horizon T of the products of the probability that an individual with aptitude x will remain in service through YOS t multiplied by the value accruing to the Air Force of an individual with aptitude x in YOS t multiplied times the productive capacity (Faneuff et al., 1990) of an individual with aptitude x in YOS t. The expected value of an individual with aptitude x over the horizon T, $EV_{x,k}$, can be expressed as,

$$EV_{x,k} = \sum_{t=0}^{T} [S_{x,k,t} \times V_{x,k,t} \times PC_{x,k,t}] \qquad \text{(A-5)}$$

where,

$S_{x,k,t}$ is the probability that an individual with aptitude x in AFS/Cluster k will remain in service through YOS t,

$V_{x,k,t}$ is the value to the Air Force of the services provided by an individual of aptitude x in AFS/Cluster k in YOS t, and

$P_{x,k,t}$ is the productive capacity of an individual with aptitude x in AFS/Cluster k in YOS t.

Estimation of Expected Cost

The expected cost of an individual with aptitude x over horizon T, EC_x, equals the summation over horizon T of the products of the probability that an individual with aptitude x will remain in service through YOS t multiplied by the cost to the Air Force of an individual with aptitude x in YOS t (Faneuff et al., 1990), which can be expressed as,

$$EC_{x,k} = \sum_{t=0}^{T} [S_{x,k,t} \times C_{x,k,t}] \qquad \text{(A-6)}$$

where,

$C_{x,k,t}$ is the cost to the Air Force of maintaining and/or training an individual with aptitude x in AFS/Cluster k in YOS t and

$S_{x,k,t}$ is the same as in Equation A-5.

Estimation of Expected Total Net Return

Thus, the expected total net return of an individual with aptitude x over horizon T, $ETNR_{x,k}$, is the difference between expected value and expected cost over horizon T and can be expressed as,

$$ETNR_{x,k} = EV_{x,k} - EC_{x,k} \quad \text{(A-7)}$$

or

$$ETNR_{x,k} = \sum_{t=0}^{T} [S_{x,k,t} \times V_{x,k,t} \times PC_{x,k,t}] - \sum_{t=0}^{T} [S_{x,k,t} \times C_{x,k,t}] \quad \text{(A-8)}$$

Thus, SUMS will allocate accessions in order to maximize the expected total net return, which can be expressed as (similar to Equation A-1),

$$\sum_{k=1}^{K} \sum_{x=1}^{M} (ETNR_{x,k} \times n_{x,k}) \quad \text{(A-9)}$$

where,

$\mathbf{ETNR_{x,k}}$ is the expected net return to the Air Force of maintaining and/or training an individual with aptitude **x** in AFS **k** over a user-specified time horizon and

$\mathbf{n_{x,k}}$ is the number of accessions with aptitude **x** assigned to AFS/Cluster **k**.

Total Productive Capacity

Productive capacity, $\mathbf{PC_{x,k,t}}$, is calculated for each aptitude group **x** of the eligible applicant pool for each YOS **t** that an applicant could serve for each AFS/Cluster **k** to which an applicant could be allocated. The allocation criterion, $\mathbf{TPC_{x,k}}$, for an individual with aptitude **x** in a particular AFS/Cluster **k** is equal to the sum of the productive capacity to be attained each year of additional experience **t** over a given horizon **T**.

$$TPC_{x,k} = \sum_{t=0}^{T} PC_{x,k,t} \quad \text{(A-10)}$$

where,

$\mathbf{PC_{x,k,t}}$ is the productive capacity of an individual with aptitude **x** in AFS/Cluster **k** in YOS **t** and

$\mathbf{TPC_{x,k}}$ is the sum of the productive capacity attainable over a specified horizon **T** for an individual with aptitude **x** in AFS **k**.

Accessions are allocated by maximizing total system productivity for each projection year, which can be expressed as (similar to Equation A-1),

$$\sum_{k=1}^{K}\sum_{x=1}^{M}(TPC_{x,k}\times n_{x,k}) \qquad \text{(A-11)}$$

where,

$\mathbf{n_{x,k}}$ is the number of accessions with aptitude **x** assigned to AFS/Cluster **k**.

Total Value

The allocation criterion total value (**TV**) is the value to the Air Force of the services provided by an individual with aptitude **x** in AFS **k** over a horizon **T**. Value, $\mathbf{V_{x,k,t}}$, is calculated for each aptitude group **x** of the eligible applicant pool for each YOS **t** that an applicant could serve for each AFS/Cluster **k** to which an applicant could be allocated. The allocation criterion, $\mathbf{TV_{x,k}}$, for an individual with aptitude **x** in a particular AFS/Cluster **k** is equal to the sum of the value to be attained each year of additional experience **t** over a given horizon **T**.

$$TV_{x,k}=\sum_{t=0}^{T}V_{x,k,t} \qquad \text{(A-12)}$$

where,

$\mathbf{V_{x,k,t}}$ is the value to the Air Force of services provided by an individual with aptitude **x** in AFS/Cluster **k** in YOS **t** and

$\mathbf{TV_{x,k}}$ is the sum of the value attainable over a specified horizon **T** for an individual with aptitude **x** in AFS **k**.

Accessions are allocated by maximizing total system value for each projection year, which can be expressed as (similar to Equation A-1),

$$\sum_{k=1}^{K}\sum_{x=1}^{M}(TV_{x,k}\times n_{x,k}) \qquad \text{(A-13)}$$

where,

$\mathbf{n_{x,k}}$ is the number of accessions with aptitude **x** assigned to AFS/Cluster **k**.

Total Cost

The allocation criterion total cost (**TC**) is the cost to the Air Force of maintaining and/or training an individual with aptitude **x** in AFS **k** over horizon **T**. Cost, $\mathbf{C_{x,t}}$, is calculated for each aptitude group **x** of the eligible applicant pool for each YOS **t** that an applicant could serve for

each AFS/Cluster **k** to which an applicant could be allocated. The allocation criterion, $TC_{x,k}$, for an individual with aptitude **x** in a particular AFS/Cluster **k** is equal to the sum of the costs to be incurred each year of additional experience **t** over a given horizon **T**.

$$TC_{x,k} = \sum_{t=0}^{T} C_{x,k,t} \qquad \text{(A-14)}$$

where,

$C_{x,k,t}$ is the cost to the Air Force of maintaining and/or/training an individual with aptitude **x** in AFS/Cluster **k** in YOS **t** and

$TC_{x,k}$ is the sum of the costs incurred over a specified horizon **T** for an individual with aptitude **x** in AFS **k**.

Accessions are allocated by minimizing total system cost for each projection year, which can be expressed as (similar to Equation A-1),

$$\sum_{k=1}^{K} \sum_{x=1}^{M} (TC_{x,k} \times n_{x,k}) \qquad \text{(A-15)}$$

where,

$n_{x,k}$ is the number of accessions with aptitude **x** assigned to AFS/Cluster **k**.

Expected Total Productive Capacity

Expected productive capacity is calculated for each aptitude group **x** of the eligible applicant pool for each YOS **t** that an applicant could serve for each AFS/Cluster **k** to which an applicant could be allocated considering the probability that an individual with aptitude **x** will remain in service through YOS **t** in AFS/Cluster **k**, $S_{x,k,t}$. The allocation criterion, $ETPC_{x,k}$, for an individual with aptitude **x** in a particular AFS/Cluster **k** is equal to the sum of the productive capacity to be attained each year of additional experience **t** over a given horizon **T**.

$$ETPC_{x,k} = \sum_{t=0}^{T} [S_{x,k,t} \times PC_{x,k,t}] \qquad \text{(A-16)}$$

where,

$S_{x,k,t}$ is the probability that an individual with aptitude **x** will remain in service through YOS **t** in AFS **k**,

$P_{x,k,t}$ is the productive capacity of an individual with aptitude **x** in YOS **t** and AFS **k**, and

$\mathbf{ETPC_{x,k}}$ is the sum of the expected productive capacity attainable over a specified horizon **T** for an individual with aptitude **x** in AFS **k**.

Accessions are allocated by maximizing total system expected productive capacity for each projection year, which can be expressed as (similar to Equation A-1),

$$\sum_{k=1}^{K}\sum_{x=1}^{M}(ETPC_{x,k}\times n_{x,k}) \qquad \text{(A-17)}$$

where,

$\mathbf{n_{x,k}}$ is the number of accessions with aptitude **x** assigned to AFS/Cluster **k**.

Expected Total Value

Expected value is calculated for each aptitude group **x** of the eligible applicant pool for each YOS **t** that an applicant could serve for each AFS/Cluster **k** to which an applicant could be allocated considering the probability that an individual with aptitude **x** will remain in service through YOS **t**, $\mathbf{S_{x,k,t}}$. The allocation criterion value $\mathbf{ETV_{x,k}}$ for an individual with aptitude **x** in a particular AFS/Cluster **k** is equal to the sum of the expected value to be attained each year of additional experience **t** over a given horizon **T**.

$$ETV_{x,k}=\sum_{t=0}^{T}[S_{x,k,t}\times V_{x,k,t}] \qquad \text{(A-18)}$$

where,

$\mathbf{S_{x,k,t}}$ is the probability that an individual with aptitude **x** will remain in service through YOS **t** in AFS **k**,

$\mathbf{V_{x,k,t}}$ is the value to the Air Force of services provided by an individual with aptitude **x** in YOS **t** and AFS **k**, and

$\mathbf{ETV_{x,k}}$ is the sum of the expected value attainable over a specified horizon **T** for an individual with aptitude **x** in AFS **k**.

Accessions are allocated by maximizing total system expected value for each projection year, which can be expressed as (similar to Equation A-1),

$$\sum_{k=1}^{K}\sum_{x=1}^{M}(ETV_{x,k}\times n_{x,k}) \qquad \text{(A-19)}$$

where,

$n_{x,k}$ is the number of accessions with aptitude x assigned to AFS/Cluster k.

Expected Total Cost

Expected total cost is calculated for each aptitude group x of the eligible applicant pool for each YOS t that an applicant could serve for each AFS/Cluster k to which an applicant could be allocated considering the probability that an individual with aptitude x will remain in service through YOS t, $S_{x,k,t}$. The allocation criterion value $ETC_{x,k}$ for an individual with aptitude x in a particular AFS/Cluster k is equal to the sum of the expected total cost to be incurred for each year of additional experience t over a given horizon T.

$$ETC_{x,k}=\sum_{t=0}^{T}[S_{x,k,t}\times C_{x,k,t}] \qquad \text{(A-20)}$$

where,

$S_{x,k,t}$ is the probability that an individual with aptitude x will remain in service through YOS t in AFS k,

$C_{x,k,t}$ is the cost to the Air Force of maintaining and/or/training an individual with aptitude x in YOS t and AFS k, and

$ETC_{x,k}$ is the sum of the expected total cost incurred over a specified horizon T for an individual with aptitude x in AFS k.

Accessions are allocated by minimizing total system expected cost for each projection year, which can be expressed as (similar to Equation A-1),

$$\sum_{k=1}^{K}\sum_{x=1}^{M}(ETC_{x,k}\times n_{x,k}) \qquad \text{(A-21)}$$

where,

$n_{x,k}$ is the number of accessions with aptitude x assigned to AFS/Cluster k.

Accession Allocation With a Single Aptitude Scale

Assume that a single aptitude measure is adequate for establishing the link between job performance and classification across all AFSs in the Air Force. Also, assume a given distribution of aptitude scores from a given applicant pool. The applicant pool is stratified by aptitude categories so that the available scores for each aptitude category are known. For

example, a_{90} would include all available scores of 90 to 99, a_{80} would include all available scores from 80 to 89, a_{70} would include all available scores from 70 to 79, etc. These available scores are denoted by $\mathbf{a_x}$, where **x** represents the aptitude category.

For modeling purposes, assume the user desires to minimize the expected total cost in the allocation of new recruits across all AFSs for the Air Force. Also assume that there is a projected new recruit manning requirement for each AFS, denoted by $\mathbf{r_k}$. The minimum cost allocation for the Air Force as a whole based on the applicant pool stratification is obtained by minimizing:

$$\sum_{k=1}^{K}\sum_{x=1}^{M}(ETC_{x,k}\times n_{x,k}) \qquad \textbf{(A-22)}$$

subject to the constraints:

$$\sum_{k=1}^{K} n_{x,k} \le a_x \qquad \text{for all } \mathbf{x} \qquad \textbf{(A-23)}$$

$$\sum_{x=1}^{M} n_{x,k} \le r_k \qquad \text{for all } \mathbf{x} \qquad \textbf{(A-24)}$$

$$n_{x,k} \ge 0 \qquad \text{for all } \mathbf{x} \text{ and } \mathbf{k} \qquad \textbf{(A-25)}$$

where,

$\mathbf{ETC_{x,k}}$ is the sum of the expected total cost for an individual with aptitude **x** in AFS **k**,
$\mathbf{n_{x,k}}$ is the number of recruits with aptitude **x** assigned to AFS **k**,
a_x is the number of recruits with aptitude **x**, and
$\mathbf{r_k}$ is the manning requirement for AFS **k**.

The objective function (Equation A-22) being minimized is the product of the cost per productive unit (or recruit) and the number of recruits of aptitude **x** assigned to AFS **k**. Thus, the overall cost per productive unit of manning the force is being minimized.

Single Aptitude Model Example

To illustrate this model, consider a hypothetical force containing two AFSs with an applicant pool consisting of potential recruits of three aptitude categories. In addition, assume the following expected total costs by AFS and aptitude level as shown in Table A-1. Manning requirements by AFS and the number of recruits available from the applicant pool by aptitude are also shown in Table A-1.

Table A-1. Expected Total Cost by Aptitude Category

Aptitude	AFS_1	AFS_2	a_x
90	$3,264	$2,900	100
80	$3,523	$4,200	200
70	$3,829	$5,000	300
r_k	300	250	---

Given this hypothetical force, the objective function being minimized would be:

$$\$3264 n_{90,1} + \$2900 n_{90,2} + \$3523 n_{80,1} + \$4200 n_{80,2} + \$3829 n_{70,1} + \$5000 n_{70,2} \quad \text{(A-26)}$$

subject to the following constraints:

$$\begin{aligned} n_{90,1} + n_{90,2} &\le 100 \\ n_{80,1} + n_{80,2} &\le 200 \\ n_{70,1} + n_{70,2} &\le 300 \end{aligned} \quad \text{(A-27)}$$

$$\begin{aligned} n_{90,1} + n_{80,1} + n_{70,1} &\le 300 \\ n_{90,2} + n_{80,2} + n_{70,2} &\le 250 \end{aligned} \quad \text{(A-28)}$$

$$n_{x,k} \ge 0 \qquad \text{for all } \mathbf{x} \text{ and } \mathbf{k} \quad \text{(A-29)}$$

The allocation of recruits from the available applicant pool for this problem which would minimize expected total cost, $\mathbf{ETC_{x,k}}$ for the hypothetical force would be:

$$\begin{aligned} \mathbf{n}_{90,1} &= 0 & \mathbf{n}_{90,2} &= 100 \\ \mathbf{n}_{80,1} &= 50 & \mathbf{n}_{80,2} &= 150 \\ \mathbf{n}_{70,1} &= 250 & \mathbf{n}_{70,2} &= 0 \end{aligned}$$

with a total expected cost for the force of $2,053,400. No other allocation of recruits from the given applicant pool to the two AFS, given the expected costs and manning requirements of each AFS, could result in a lower expected total cost.

Accession Allocation with a Multiple Aptitude Model

The single aptitude scale is not appropriate for the allocation of recruits across all AFSs in the Air Force. The mathematical programming model, or accession allocation algorithm can be extended to encompass multiple aptitude scales by further stratifying the applicant pool. This extension causes no conceptional difficulties, but does increase the computational effort required to solve the resulting allocation problem.

Consider that the expected total cost functions are dependent on one or more aptitude measures. For instance, the productivity of some AFSs may be dependent on the mechanical (M) composite aptitude score. For other AFSs, performance may be more closely related to the electronics (E) composite aptitude score. Still other AFSs may need two or more aptitude scales to appropriately capture their effectiveness measures. This situation requires that the minimum cost allocation model incorporate multiple aptitude scales. This is accomplished in the following model.

Let the aptitude space be defined by an n-tuple stratification of specific aptitude scales, $\mathbf{x} = (x_1, x_2, \ldots, x_m)$, where each component of $\mathbf{x}$ represents the value of a particular aptitude score. The expected cost functions for each AFSs $\mathbf{k}$ are then represented as functions of $\mathbf{x}$, $\mathbf{ETC}_{x,k}$. To develop the appropriate mathematical model from which the minimum cost allocation of the available recruit pool can be determined, the applicant pool must be partitioned across every aptitude scale. The result of this multiple partitioning scheme is that each cell in the partition has an aptitude measure which can be represented by specific values of the aptitude vector $\mathbf{x}$. The decision variables for the number of individual recruits allocated to each AFS specialty are also functions of this multiple aptitude scale, $\mathbf{n}_{x,k}$. Then the general model to be minimize is represented by the equation:

$$\sum_{k=1}^{K}\sum_{x=1}^{M}(ETC_{x,k}\times n_{x,k}) \qquad \textbf{(A-30)}$$

subject to the constraints:

$$\sum_{k=1}^{K} n_{x,k} \le a_x \qquad \text{for all partitions of } \mathbf{x} \qquad \textbf{(A-31)}$$

$$\sum_{x=1}^{M} n_{x,k} \le r_k \qquad \text{for all } \mathbf{k} \qquad \textbf{(A-32)}$$

$$n_{x,k} \ge 0 \qquad \text{for all } \mathbf{x} \text{ and } \mathbf{k} \qquad \textbf{(A-33)}$$

Note that the summation over the multiple aptitude scale represents a multiple summation over each individual scale in the aptitude partition.

Multiple Aptitude Example

Once again, consider the example problem of allocating recruits among two AFSs from a given applicant pool with a single aptitude measure partitioned into categories of 70, 80, and 90. Assume that the first aptitude scores were electronics (E) scores and that a second set of scores, mechanical (M), are also available for this recruit pool. For purpose of discussion, the E scores are partitioned into 90, 80 and 70 and that M scores are partitioned into only two categories, 60 and 80 for simplicity of the example. This applicant pool will now have six cells. The following distribution and expected costs for the example force are shown in Table A-2.

Table A-2. Expected Total Cost by Multiple Aptitude Category

Aptitude E/M	AFS_1	AFS_2	a_x
90/80	\$3,300	\$2,900	40
90/60	\$3,400	\$3,100	60
80/80	\$3,500	\$4,200	80
80/60	\$3,700	\$4,500	120
70/80	\$3,900	\$5,000	150
70/60	\$4,100	\$5,200	150
r_k	300	200	---

Given this hypothetical force, the resulting objective function being minimized for the two aptitude scale model would be:

$$\begin{aligned} &\$3300n_{90,80,1} + \$2900n_{90,80,2} + \$3400n_{90,60,1} + \$3100n_{90,60,2} + \\ &\$3500n_{80,80,1} + \$4200n_{80,80,2} + \$3700n_{80,60,1} + \$4500n_{80,60,2} + \\ &\$3900n_{70,80,1} + \$5000n_{70,80,2} + \$4100n_{70,60,1} + \$5200n_{70,60,2} \end{aligned} \quad \text{(A-34)}$$

subject to the constraints:

$$\begin{aligned} n_{90,80,1} + n_{90,80,2} &\le 40 \\ n_{90,60,1} + n_{90,60,2} &\le 60 \\ n_{80,80,1} + n_{80,80,2} &\le 80 \\ n_{80,60,1} + n_{80,60,2} &\le 120 \\ n_{70,80,1} + n_{70,80,2} &\le 150 \\ n_{70,60,1} + n_{70,60,2} &\le 150 \end{aligned} \qquad \text{(A-35)}$$

$$\begin{aligned} n_{90,80,1} + n_{90,60,1} + n_{80,80,1} + n_{80,60,1} + n_{70,80,1} + n_{70,60,1} &\le 300 \\ n_{90,80,2} + n_{90,60,2} + n_{80,80,2} + n_{80,60,2} + n_{70,80,2} + n_{70,60,2} &\le 200 \end{aligned} \qquad \text{(A-36)}$$

$$n_{x,k} \ge 0 \qquad \text{for all } \mathbf{x} \text{ and } \mathbf{k} \qquad \text{(A-37)}$$

The minimization of cost for the multiple aptitude recruiting pool results in a linear programming problem identical in nature to the single aptitude scale problem. The solution to this example problem which minimizes expected total cost, $\mathbf{ETC_{x,k}}$, for this hypothetical force is:

$\mathbf{n}_{90,80,1} = 0$	$\mathbf{n}_{90,80,2} = 40$
$\mathbf{n}_{90,60,1} = 0$	$\mathbf{n}_{90,60,2} = 60$
$\mathbf{n}_{80,80,1} = 0$	$\mathbf{n}_{80,80,2} = 80$
$\mathbf{n}_{80,60,1} = 100$	$\mathbf{n}_{80,60,2} = 100$
$\mathbf{n}_{70,80,1} = 150$	$\mathbf{n}_{70,80,2} = 0$
$\mathbf{n}_{70,60,1} = 50$	$\mathbf{n}_{70,60,2} = 0$

The size of the problem grows as the product of the number of aptitude scales and their respective partition sizes increases.

APPENDIX B

Optimization of the Steady State

The optimization module in SUMS provides the user with the ability to select from seven alternative objectives for determining the steady state flow of accessions:

(1) Maximize Expected Total Net Return,
(2) Maximize Total Productive Capacity,
(3) Maximize Total Value,
(4) Minimize Total Cost,
(5) Maximize Expected Total Productive Capacity,
(6) Maximize Expected Total Value, and
(7) Minimize Expected Total Cost.

In the theoretical example presented below, the user has chosen to minimize total cost over the career of the accessions. Thus, the optimization scheme will search for the optimal steady-state flow of accessions by aptitude mix by Air Force specialty (AFS) which will minimize the total cost of the force over the careers of the accessions.

Let the experience scale be represented by years of service (YOS) from 0, 1, 2,..., to **t**. For a given AFS, **k**, and accession aptitude mix, let the continuation probabilities $\mathbf{p}_t$ represent the probability of an individual of experience **t** continuing to experience group **t+1**. For this example, the aptitude score will be consist of only 4 outcomes (4-tuple). Given the steady-state flow of accessions, **f**, the number $\mathbf{g}_t$ of these cohorts that remain for the various experience terms are:

$$\begin{aligned} \mathbf{g}_0 &= \mathbf{f}, \\ \mathbf{g}_1 &= \mathbf{p}_0\mathbf{g}_0, \\ \mathbf{g}_2 &= \mathbf{p}_1\mathbf{g}_1. \\ &\vdots \\ \mathbf{g}_t &= \mathbf{p}_{t-1}\mathbf{g}_{t-1}. \end{aligned} \qquad \textbf{(B-1)}$$

In the steady state, the number of accessions entering each year, **f**, must equal the total number of separations. This leads to the following system of equations representing the proportional description of the AFS-aptitude group as:

$$(\pi_0, \pi_1, \ldots, \pi_t)P = (\pi_0, \pi_1, \ldots, \pi_t) \qquad \textbf{(B-2)}$$

where ***P*** is a matrix of continuation probabilities. This system of equations, with the additional restriction that the proportions add to one, yields:

$$\pi_{t+1} = p_t \pi_t \tag{B-3}$$

$$\pi_0 = \frac{1}{1 + p_0 + p_0 p_1 + p_0 p_1 p_2 + \ldots + p_0 \ldots p_{t-1}} \tag{B-4}$$

The π elements are all that are needed to completely represent the total steady-state profile for the specified experience-aptitude force. The total number of individuals in the force given the number of accessions **f** equals $\frac{f}{\pi_0}$. Another way to view the steady-state accession flow, **f**, is that **f** is the number of annual accessions necessary to maintain the force size $\frac{f}{\pi_0}$. The value of π_0 represents the force level attrition rate.

Steady-State Total Cost Minimization Given End Strengths by AFS

Assume the user desires to find the steady-state aptitude mix by AFS when minimizing the total cost over the career of the recruit. Let $f_{x_1,x_2,x_3,x_4,k}$ be the number of accessions in steady-state by AFS **k** and 4-tuple aptitude group **x**. Let $TC_{x_1,x_2,x_3,x_4,k}$ be the total cost associated with this group. Let $\pi_{0,x_1,x_2,x_3,x_4,k}$ be the steady-state proportion in experience category **0** for this group. The manning requirements for each AFS **k** is represented by $\mathbf{r_k}$. Finally, let a_{x_1,x_2,x_3,x_4} be the number of available applicants in the accession pool by aptitude category. Then the minimum cost steady-state manning model for a given applicant pool mix may be obtained from minimizing:

$$\sum_{x_1}\sum_{x_2}\sum_{x_3}\sum_{x_4}\sum_{k} \frac{TC_{x_1,x_2,x_3,x_4,k}}{\pi_{0,x_1,x_2,x_3,x_4,k}} f_{x_1,x_2,x_3,x_4,k} \tag{B-5}$$

subject to the constraints:

$$\sum_{x_1}\sum_{x_2}\sum_{x_3}\sum_{x_4} \frac{f_{x_1,x_2,x_3,x_4,k}}{\pi_{0,x_1,x_2,x_3,x_4,k}} = r_k \tag{B-6}$$

$$\sum_k f_{x_1,x_2,x_3,x_4,k} \leq a_{x_1,x_2,x_3,x_4} \qquad \text{for all } \mathbf{x} \qquad \text{(B-7)}$$

$$f_{x_1,x_2,x_3,x_4,k} \geq 0 \qquad \text{for all } \mathbf{x} \text{ and } \mathbf{k} \qquad \text{(B-8)}$$

Two AFS, Two Aptitude Group Example

To illustrate the optimization model, consider a force consisting of two AFSs with an applicant pool consisting of two test categories, $\mathbf{x}_1$ and $\mathbf{x}_2$. Each test category has two possible scores, 60 and 80, where a score of 80 is a higher aptitude rating than a score of 60. In this example, aptitude $\mathbf{x}_1$ is the selector aptitude index (AI) used for $\mathbf{AFS}_1$ and $\mathbf{x}_2$ is the selector AI used for $\mathbf{AFS}_2$. The cost by AFS and aptitude category is shown in Table B-1 in hundreds of thousands of dollars. Manning requirements and applicant availability are also shown in Table B-1.

Table B-1. Total Cost by Aptitude Category

Aptitude x_1/x_2	AFS_1 (x_1)	AFS_2 (x_2)	$a_{x1,x2}$
80/80	$1.3952	$1.3640	11
80/60	$1.3952	$1.3640	10
60/80	$1.3952	$1.3640	7
60/60	$1.3952	$1.3640	8
r_k	100	110	----

The values for π_0 and $\frac{1}{\pi_0}$ are provided in Table B-2. The continuation rates for aptitudes of 60 and 80 for test $\mathbf{x}_1$ for $\mathbf{AFS}_1$, are slightly different as indicated by the values for π_0. The $\frac{1}{\pi_0}$ value for aptitude 60 for test $\mathbf{x}_1$ for $\mathbf{AFS}_1$ reflects a slightly higher set of continuation rates compared to $\frac{1}{\pi_0}$ for aptitude 80 for test $\mathbf{x}_1$ for $\mathbf{AFS}_1$. The $\frac{1}{\pi_0}$ value for test $\mathbf{x}_2$ for $\mathbf{AFS}_2$, reflects a similar pattern, though the magnitudinal differences are much larger as shown in Table B-2.

The $\frac{1}{\pi_0}$ for aptitude 60 for test x_1 for AFS_1 of 9.2851 is the inventory level which would exist if a single recruit of aptitude 60 from test x_1 entered the service in AFS_1 every year for 30 years, assuming no change in the continuation rates over the 30 year period. Thus, $\frac{1}{\pi_0}$ represents a survival rate for personnel of aptitude x in AFS k. The survival rate for aptitude 80 in both AFSs is generally higher over the 30 year period than the survival rates for aptitude 60 as reflected by the differences in the $\frac{1}{\pi_0}$ values.

Table B-2. Continuation Rates by AFS and Aptitude

	AFS_1 $x_1 = 60$	AFS_1 $x_1 = 80$	AFS_2 $x_2 = 60$	AFS_2 $x_2 = 80$
π_0	0.1077	0.1069	0.1059	0.0979
$\frac{1}{\pi_0}$	9.2851	9.3545	9.4429	10.2145

In our example, the total cost function which will be minimized is defined as:

$$\begin{aligned}&(\frac{1.3952}{0.1077})f_{60,60,1} + (\frac{1.3952}{0.1077})f_{60,80,1} + \\ &(\frac{1.3952}{0.1069})f_{80,60,1,} + (\frac{1.3952}{0.1069})f_{80,80,1} + \\ &(\frac{1.3640}{0.1059})f_{80,80,2} + (\frac{1.3640}{0.1059})f_{80,60,2} + \\ &(\frac{1.3640}{0.0979})f_{60,80,2} + (\frac{1.3640}{0.0979})n_{80,80,2}\end{aligned} \qquad \textbf{(B-8)}$$

subject to the constraints:

$$
\begin{aligned}
&\left(\frac{1}{0.1077}\right)f_{60,60,1} + \left(\frac{1}{0.1077}\right)f_{60,80,1} + \\
&\left(\frac{1}{0.1069}\right)f_{80,60,1} + \left(\frac{1}{0.1069}\right)f_{80,80,1} = 100 \\
&\left(\frac{1}{0.1059}\right)f_{60,60,2} + \left(\frac{1}{0.0979}\right)f_{60,80,2} + \\
&\left(\frac{1}{0.1059}\right)f_{80,60,2} + \left(\frac{1}{0.0979}\right)f_{80,80,2} = 110
\end{aligned}
\qquad \text{(B-9)}
$$

$$
\begin{aligned}
f_{60,60,1} + f_{60,60,2} &\le 8 \\
f_{80,60,1} + f_{80,60,2} &\le 10 \\
f_{60,80,1} + f_{60,80,2} &\le 7 \\
f_{80,80,1} + f_{80,80,2} &\le 11
\end{aligned}
\qquad \text{(B-10)}
$$

where,

$f_{x_1,x_2,k}$ is the number of accessions with aptitude x_1 and x_2 are accessed into the **k**th AFS.

The fractions in the total cost function are equal to the cost for an accession with scores x_1 and x_2 in the *k*th AFS divided by $\pi_{0,x_1,x_2,k}$. The fraction does not change in value unless the test score of the appropriate selector AI for that AFS changes. Thus, the fraction for $\mathbf{f}_{60,60,1}$ and $\mathbf{f}_{60,80,1}$ are equal since only the test score for test 2 changed from 60 to 80, and the selector AI for $\mathbf{AFS}_1$ is test 1. Conversely, the fractions for $\mathbf{f}_{60,60,1}$ and $\mathbf{f}_{80,60,1}$ are different because the test score for test 1, which is the selector AI for $\mathbf{AFS}_1$, did change from 60 to 80.

Given the above values for the π_0's and cost, the steady state flow of accessions which minimize the total cost of the system of two AFSs is presented in Table B-3.

Table B-3. Steady State Accession Flow by Aptitude and AFS

Aptitude (x_1,x_2)	AFS_1	AFS_2	Total Used	Total Available	Total Unused
60,60	0.000	0.000	0.000	8.000	8.000
60,80	0.000	7.000	7.000	7.000	0.000
80,60	10.000	0.000	10.000	10.000	0.000
80,80	0.690	4.748	5.438	11.000	5.562
Total	10.690	11.748	22.438	36.000	13.562

The accession flow presented in Table B-3 is the optimal allocation of recruits from the applicant pool which will minimize the total cost associated with the optimal force profile given the costs presented in Table B-1, the π_0 *'s* presented in Table B-2. Accessions for $\mathbf{AFS_1}$ are comprised of two groups of individuals, those with test scores of (80,60) and (80,80), while accessions for $\mathbf{AFS_2}$ are comprised of two groups of individuals, those with test scores of (60,80) and (80,80). Individuals with test scores of (60,60) or (60,80) were not allocated to $\mathbf{AFS_1}$, and individuals with test scores of (80,60) and (60,60) were not allocated to $\mathbf{AFS_2}$.

The force profile which would exist in the steady state is provided in Table B-4. As indicated in Table B-4, the inventories requirements for each AFS are met, $\mathbf{AFS_1}$ has an inventory of 100 and $\mathbf{AFS_2}$ has an inventory of 110. Thus, the steady state allocation of accessions to AFSs meets the specified inventory requirements (Equation B-9), and, thus, the total force level goals, i.e., the sum of the manning requirements across AFSs (100 + 110).

Table B-4. Steady-State Force Profile

YOS	AFS_1 $x_1 = 80$	AFS_2 $x_2 = 80$
0	10.690000	11.748000
1	10.159770	9.876491
2	9.465863	9.007359
3	8.768229	8.223719
4	5.375801	6.380783
5	4.855423	5.648269
6	4.315986	4.860336
7	3.886545	4.400062
8	3.617985	4.136058
9	3.406333	3.932564
10	3.236016	3.831890
11	3.125021	3.419196
12	3.037832	3.343973
13	2.941837	3.176775
14	2.841520	3.176775
15	2.804581	3.151678
16	2.790277	3.151678
17	2.790277	3.101567
18	2.768234	3.101567
19	2.768234	3.101567
20	1.693882	2.326175
21	1.137611	1.633905
22	0.929769	1.270851
23	0.638380	1.001304
24	0.522322	0.858217
25	0.428565	0.715152
26	0.379109	0.514910
27	0.284331	0.429074
28	0.174977	0.353342
29	0.154400	0.332566
30	0.051461	0.083141
Total	100.040500	110.288900

APPENDIX C

AFSs Excluded in SUMS

This appendix contains a listing of the AFSs from the 31 October 1990 Airman Classification Structure Chart which were excluded from SUMS. These AFSs were excluded from SUMS because they did not contain entry-level positions in accordance with AFR 39-1. Special duty identifiers and reporting identifiers also were excluded from SUMS. SUMS can presently on simulate or optimize using AFSs with entry-level positions. No retraining paths exist in SUMS to account for flows of personnel into and out-of these AFSs which have been excluded. AFSs with extremely low manning levels were also excluded from SUMS. The following AFSs were not included in SUMS:

100x0	First Sergeant
113x0	Flight Engineer
241x0	Safety
242x0	Disaster Preparedness
341x2	Defensive Systems Trainer
341x4	Flight Simulator
341x6	Navigation/Tactical Training Devices
341x7	Missile Trainer
472x4	Vehicle Maintenance Control & Analysis
492x2	Communication Systems Electromagnetic Spectrum Management
545x3	CE Controls Systems
591x0	Seaman
591x1	Marine Engine
612x0	Meatcutter
645x2	Supply Systems Analysis
661x0	Logistics Plans
674x0	Cost Analysis
733x1	Manpower Management
734x0	Social Actions
742x0	Open Mess Management
751x1	Training Systems
753x1	Gunsmith
792x2	Historian
821x0	Special Investigations
872x0	Instrumentalist
881x0	Paralegal
903x1	Nuclear Medicine
925x0	Cytotechnology
99000	Basic Airman

99001	Officer Trainee
99002	Patient
99005	Airman Awaiting Discharge, Separation, Retirement
99006	Airman Awaiting Retraining
99007	Airman Ineligible for Local Util
99008	Prisoner
99009	Air Awaiting Retraining
99101	Precadet Assignee
99102	Airman Aid
99103	Interpreter/Translator
99107	Senior Enlisted Advisor
99108	Chief Master Sergeant of the Air Force
99500	Recruiter
99501	Research & Development Technician
99502	Military Training Instructor
99503	USAF Honor Guard
99504	Missile Facility Manager
99505	Courier
99600	Student Training Adviser
99602	Sensor Operator
99603	ICBM NCO Code Controller
99604	Postal Specialist
99605	PME Instructor
99606	Linguist Debriefer/Interrogator
99700	Family Support Center Superintendent
99701	In-Flight Passenger Service Specialist
99702	Correctional Custody Supervisor
99703	Defense Attache Specialist

20 MAGE Clusters

The following clusters are based on the minimum selector AI score, M, A, G, or E, required for admittance into the AFS. The clusters are comprised of those AFSs with the same designated aptitude requirements, M, A, G, or E, and similar minimum score requirements. For example, cluster 1 is comprised of those AFSs with a minimum mechanical (M) score requirement between 61 and 57, while cluster 2 includes those AFSs with a minimum mechanical (M) score requirement between 51 and 50. The range of scores within a cluster is arbitrary and could be larger or smaller depending on whether more or fewer clusters are desired. Other factors to be considered are the actual differences of the AFSs included in a cluster, as well as the difficulty of constructing parameters of the cluster to be used in SUMS. This methodology results in 20 clusters of AFSs.

Cluster No.	AFS	AI	Score	Description
(1)	454x2	M	58	Aircrew Egress Systems Mechanic
	454x4			Aircraft Pneudraulic Systems
	457x1			Helicopter Maintenance
	463x0			Nuclear Weapons
	472x3			Vehicle Body Mechanic
	753x1			Gunsmith
(2)	361x0	M	51	Antenna Systems Installation/Maintenance
	361x1			Communication Cable Systems Installation/Maintenance
	411x1			Missile Maintenance
	452x4			Tactical Aircraft Maintenance
	454x0			Aerospace Propulsion
	454x3			Aircraft Fuel Systems
	457x0			Strategic Aircraft Maintenance
	457x2			Airlift Aircraft Maintenance
	458x0			Aircraft Metals Technology
	458x2			Aircraft Structural Maintenance
	472x0			Special Purpose Vehicle & Equipment Mechanic
	472x2			General Purpose Vehicle Mechanic
	545x1			Liquid Fuel Systems Maintenance
	552x0			Structural
	552x5			Plumbing
(3)	458x3	M	44	Fabrication & Parachute
	472x1			Special Vehicle Mechanic
	551x0			Pavements Maintenance
	551x1			Construction Equipment
	552x2			Metal Fabricating
	566x1			Environmental Support
	591x0			Seaman
	591x1			Marine Engine
	603x0			Vehicle Operations/Dispatch
(4)	661x0	A	63	Logistics Plans
	672x1			Financial Management
	672x2			Financial Services
	673x0			Auditing
(5)	271x1	A	45	Airfield Management
	271x2			Operations Resource Management
	472x4			Vehicle Maintenance Control & Analysis

	492x1			Communications Systems Radio Operations
	602x0			Passenger & HHG
	602x1			Freight & Packaging
	645x2			Supply Systems Analysis
	732x0			Personnel
	732x1			Personnel Affairs
(5)	612x1	A	29	Subsistence Operations
	702x0			Information Management
	741x1			Fitness & Recreation
(7)	201x1	G	68	Target Intelligence
	205x0			Electronic Intelligence Operations
	206x0			Imagery Interpreter
	208x1			Germanic Cryptologic Linguist
	208x2			Romance Cryptologic Linguist
	208x3			Slavic Cryptologic Linguist
	208x4			Far East Cryptologic Linguist
	208x5			Mid East Cryptologic Linguist
	651x0			Contracting
	733x1			Manpower Management
	791x0			Public Affairs
	791x1			Radio & TV Broadcasting
	792x2			Historian
	982x0			Dental Laboratory
(8)	111x0	G	57	Defensive Aerial Gunner
	113x0			Flight Engineer
	114x0			Aircraft Loadmaster
	201x0			Intelligence Operations
	202x0			Radio Communications Analysis
	209x0			Defensive C3CM
	231x3			Visual Information Production-Documentation
	242x0			Disaster Preparedness
	496x0			Comm-Computer Systems Plan & Program Management
	751x1			Training Systems
	924x0			Medical Laboratory
(9)	112x0	G	53	In-Flight Refueling Operations
	117x0			Airborne Warning C&C Systems Operations
	121x0			Survival Training
	241x0			Safety
	272x0			Air Traffic Control
	276x0			Aerospace Control & Warning Systems

	391x0			Maintenance Data Systems Analysis
	491x2			Communications-Computer Systems Program
	674x0			Cost Analysis
	912x5			Optometry
	913x1			Occupational Therapy
	914x0			Mental Health
(10)	207x1	G	49	Morse Systems
	207x2			Printer Systems
	274x0			Command and Control
	275x0			Tactical Air Command & Control
	553x0			Engineering Assistant
	881x0			Paralegal
	913x0			Physical Therapy
(11)	115x0	G	43	Pararescue/Recovery
	116x0			Airborne Communications Systems Operations
	222x0			Geodetic
	231x0			Visual Information Media
	231x1			Graphics
	231x2			Still Photo
	233x0			Imagery Production
	273x0			Combat Control
	392x0			Maintenance Scheduling
	458x1			Nondestructive Inspection
	491x1			Communications-Computer Systems
	492x2			Communications Systems Electromagnetic Spectrum
	555x0			Production Control
	731x0			Personnel Systems Management
	753x0			Combat Arms Training & Maintenance
	821x0			Special Investigations
(12)	901x0	G	43	Aeromedical
	902x0			Medical Service
	902x2			Surgical Service
	903x0			Radiologic
	903x1			Nuclear Medicine
	904x0			Cardiopulmonary Laboratory
	905x0			Pharmacy
	906x0			Medical Administration
	907x0			Bioenvironmental Engineering
	908x0			Environmental Medicine
	911x0			Aerospace Physiology
	915x0			Medical Material

	919x0			Orthotic
	924x1			Histopathology
	925x0			Cytotechnology
	926x0			Diet Therapy
	981x0			Dental Assistant
(13)	122x0	G	34	Aircrew Life Support
	566x0			Pest Management
	571x0			Fire Protection
	612x0			Meatcutter
	623x0			Services
	645x1			Material Storage & Distribution
	703x0			Reprographic
	751x0			Education
	811x0			Security
	811x2			Law Enforcement
(14)	303x2	E	75	AC&W Radar
	303x3			Auto Tracking Radar
	455x0			Photo & Sensors Maintenance
	455x5			Avionics Support Equipment (SE)
(15)	118x0	E	67	Airborne Computer Systems
	118x1			Airborne C&C Communications Equipment
	118x2			Airborne Radar Systems
	303x1			Air Traffic Control Radar
	304x0			Wideband Communications Equipment
	304x2			Meteorological & Navigation
	304x4			Ground Radar Communications
	304x5			Television Systems
	304x6			Satellite Communications Systems Equipment
	305x4			Electronic Computer & Switching Systems
	306x6			Secure Communications Systems Maintenance
	309x0			Space Systems Equipment Maintenance
	316x3			Instrumentation
	324x0			Precision Measurement Equipment Laboratory
	341x2			Defensive Systems Trainer
	341x4			Flight Simulator
	341x6			Navigation/Tactics Training Devices
	341x7			Missile Trainer
	411x0			Missile Systems Maintenance
(16)	451x4	E	67	F-15 Avionics Test Station & Component
	451x5			F-16/A-10 Avionics Test Station & Component

	451x6			F/FB-111 Avionics Test Station & Component
	451x7			B-1B Avionics Test Station & Component
	452x1			F-15 Avionics Systems
	452x2			F-16 Avionics Systems
	452x3			F/FB-111 Avionics Systems
	455x1			Avionics Guidance & Control Systems
	455x2			Communication & Navigation Systems
	455x3			Weapon Control Systems
	455x4			Airborne Warning & Control Radar
	455x6			Airborne Command Post Communications
	456x0			Bomb-Navigation Systems
	456x1			Electronic Warfare Systems
	456x2			Defensive Fire Control Systems (DFCS)
	457x3			B-1B & B-2 Avionics Systems
	466x0			Air Launched Missile Systems
	493x0			Communications-Computer Systems Control
	918x0			Biomedical Equipment
(17)	277x0	E	42	Space Systems Operations
	362x1			Telephone Switching
	362x3			Missile Control Communications Systems
	362x4			Telephone & Data Circuitry Equipment
	404x0			Imagery Systems Maintenance
	411x2			Missile Facilities
	542x0			Electrician
	542x1			Electric Power Line
(18)	100x0	G	42	First Sergeant
	465x0			Munitions Operations
	645x0			Inventory Management
	734x0			Social Actions
	742x0			Open Mess Management
	871x0			Band
	872x0			Instrumentalist
	893x0			Chapel Management
(19)	452x5	E	45	Tactical Electrical & Environmental Systems
	454x1			Aerospace Ground Equipment
	454x5			Strategic Electrical & Environmental Systems
	454x6			Airlift Electrical & Environmental Systems
	461x0			Munitions Systems
	462x0			Aircraft Armament Systems
	464x0			Explosive Ordinance Disposal
	542x2			Electric Power Production

	545x0			Refrigeration & Air-Conditioning
	545x2			Heating Systems
	545x3			CE Controls Systems
(20)	251x0	G	40	Weather
	605x5			Air Transportation
	631x0			Fuels

55 AFS Clusters

The following clusters are based on the ordering of AFSs in the Airman Classification Structure Chart and the selector AI score, M, A, G, or E, designated for the AFS. This methodology results in 55 clusters of AFSs. Clusters 14 and 50 were excluded from the simulation because of the nonexistence of manning authorizations or the AFSs included in the two clusters. An attempt was made in these clusterings to group AFSs with similar tasks into the same clustering, subject to the Selector AI for each AFS.

Cluster No.	AFS	AI	Score	Description
(1)	111xx	G	55	Defensive Aerial Gunner
	114xx			Aircraft Loadmaster
(2)	112xx	G	55	In-Flight Refueling
	113xx			Flight Engineer
(3)	115xx	G	40	Pararescue/Recovery
	121xx			Survival Training
	122xx			Aircrew Life Support
(4)	116xx	G	45	Airborne Command Systems
	117xx			Airborne Warning C&C Systems
(5)	201xx	G	60	Intelligence Operations & Targeting
	202xx			Radio Communications Analysis
	205xx			Electronic Intelligence Operations
	206xx			Imagery Interpreter
	207xx			Communication Collection Systems
	208xx			Cryptologic Linguist
	209xx			Defensive C3CM
(6)	222xx	G	43	Geodetic
	231xx			Visual Information Services
	233xx			Imagery Production

(7)	241xx	G	55	Safety
	242xx			Disaster Preparedness
	571xx			Fire Protection
(8)	251xx	G	64	Weather
(9)	271xx	A	45	Airfield Management
	472x4			Vehicle Maintenance Control & Analysis
	492x1			Communications Systems Radio Operations
(10)	272xx	G	50	Air Traffic Control
	273xx			Combat Control
	274xx			Command and Control
	275xx			Tactical Air Command & Control
	276xx			Aerospace Control & Warning Systems
(11)	277xx	E	58	Space Systems Operations
(12)	118xx	E	67	Airborne C&C Mission Electronic Systems
	303xx			Ground Radar
	304xx			Communications Systems
	305xx			Electronic Computer & Switching Maintenance
	306xx			Secure Communications Systems Maintenance
	309xx			Space Systems Equipment Maintenance
	362xx			Telephone & Missile Control Comm Systems
(13)	316xx	E	67	Instrumentation
	324xx			Precision Measurement Equipment Laboratory
	918xx			Biomedical Equipment
(14)	341xx	E	67	Training Devices
(15)	361xx	M	51	Antenna & Cable Systems Installation/Maintenance
(16)	391xx	G	48	Maintenance Data Systems Analysis
	392xx			Maintenance Scheduling
(17)	404xx	E	40	Imagery Systems Maintenance
(18)	411xx	G	50	Missile Systems Maintenance
(19)	451xx	E	67	Avionics Test Stations
	452x1			Avionics Systems

	452x2			Avionics Systems
	452x3			Avionics Systems
(20)	454x1	M	51	Aerospace Ground Equipment
(21)	454x0	M	51	Aerospace Propulsion
	454x2			Aircrew Egress Systems
	454x3			Aircraft Fuel Systems
	454x4			Aircraft Pneudraulic Systems
(22)	452x5	M	45	Tactical Electrical & Environmental Systems
	454x5			Strategic Electrical & Environmental Systems
	454x6			Airlift Electrical & Environmental Systems
(23)	455xx	E	67	Conventional Avionics Systems
	456xx			Offensive/Defensive Avionic Systems
	457x3			Advanced Avionic Systems
(24)	452x4	M	51	Tactical Aircraft Maintenance
	457x0			Strategic Aircraft Maintenance
	457x1			Helicopter Maintenance
	457x2			Airlift Aircraft Maintenance
	458xx			Aircraft Fabrication
(25)	461xx	M	61	Munitions Systems
	462xx			Aircraft Armament Systems
	464xx			Explosive Ordinance Disposal
(26)	463xx	M	61	Nuclear Weapons
(27)	465xx	A	45	Munitions Operations
(28)	466xx	E	67	Air Launched Missile Systems
(29)	472x0	M	50	Special Purpose & Base Maint Vehicle Equipment
	472x1			Special Vehicle Mechanic
	472x2			General Purpose Vehicle Mechanic
	472x3			Vehicle Body Mechanic
(30)	491x1	G	45	Communications-Computer Systems
	491x2			Communications-Computer Systems Programming
	492x2			Comm Systems Electromagnetic Spectrum Mgt
(31)	496x0	G	58	Comm-Computer Systems Plan & Program Mgt

(32)	542x0	E	33	Electrical
	542x1			Electric Power Line
(33)	542x2	M	51	Electric Power Production
	545x0			Refrigeration & Air-Conditioning
	545x2			Heating Systems
	545x3			CE Controls Systems
(34)	545x1	M	51	Liquid Fuel Systems Maintenance
(35)	551xx	M	44	Pavements & Construction Equipment
	552xx			Structural
	566x1			Environmental Support
(36)	553xx	G	48	Engineering Assistant
	555xx			Production Control
(37)	591xx	M	44	Vehicle Operations
	603xx			Marine
(38)	605xx	M	51	Air Transportation
(39)	612x1	A	27	Subsistence Operations
	741xx			Fitness & Recreation
(40)	566x0	G	30	Pest Management
	612x0			Meatcutter
	623x0			Services
	703xx			Reprographic
(41)	631xx	M	51	Fuels
(42)	645x0	A	45	Inventory Management
	742xx			Open Mess Management
(43)	645x1	E	30	Materiel Storage & Distribution
(44)	645x2	A	51	Supply Systems Analysis
	602xx			Traffic Management
	661xx			Logistics Plans
(45)	651xx	G	70	Contracting
	674xx			Cost Analysis

(46)	672xx	A	61	Financial Management & Services
	673xx			Auditing
(47)	702xx	A	32	Information Management
	732xx			Personnel
(48)	731x0	G	43	Personnel Systems Management
	733xx			Manpower Management
(49)	734xx	A	45	Social Actions
	893xx			Chapel Management
(50)	751xx	G	50	Education & Training
	753x0			Combat Arms Training & Maintenance
(51)	753x1	M	61	Gunsmith
(52)	791xx	G	69	Public Affairs
	792xx			Historian
	881xx			Paralegal
(53)	811xx	G	35	Security Police
	821xx			Special Investigations
(54)	871xx	A	27	Band
	872xx			Instrumentalist
(55)	901xx	G	43	Aeromedical
	902xx			Medical Service
	903xx			Radiologic
	904xx			Cardiopulmonary Laboratory
	905xx			Pharmacy
	906xx			Medical Administration
	907xx			Bioenvironmental Engineering
	908xx			Environmental Medicine
	911xx			Aerospace Physiology
	912xx			Optometry
	913xx			Biomedical Therapy
	914xx			Mental Health Service
	915xx			Medical Materiel
	919xx			Orthotic
	924xx			Medical Laboratory
	925xx			Cytotechnology
	926xx			Diet Therapy

981xx	Dental
982xx	Dental Laboratory