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The FAARRS-SHARE System and Recruiting Resource Planning

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THIS REPORT DETAILS RESEARCH AND ANALYSIS EFFORTS CONDUCTED TO IMPLEMENT AND IMPROVE THE FORECASTING AND ALLOCATING ARMY RECRUITING RESOURCES STUDY -- SEQUENTIAL HIERARCHICAL ALLOCATION OF RESOURCE ELEMENTS SYSTEMS OF MODELS. THE MODELS WERE DEVELOPED, BEGINNING IN 1990, TO ASSIST ARMY MANPOWER PLANNERS IN QUANTIFYING THE IMPACT OF RESOURCE CHANGES ON RECRUITING, AND CONCORDANTLY, THE IMPACT OF CHANGES ON RECRUITING LEVELS ON RESOURCE NEEDS. PERSONNEL TURMOIL AND CHANGEOVER CAUSED FULL-SCALE ACCEPTANCE AND IMPLEMENTATION OF THE SYSTEM, PARTICULARLY AT THE HQDA LEVEL, TO BE DELAYED. THIS REPORT DOCUMENTS AN EXAMPLE OF USE AND SUGGEST AREAS FOR IMPROVEMENT. THE SYSTEM OF MODELS APPEARS TO PROVIDE REASONABLE, REAL-TIME ANSWERS TO QUESTIONS REGARDING REQUIRED RESOURCES TO SUPPORT DIFFERENT RECRUITING SCENARIOS.

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Manpower Planning Models: The FAARRS-SHARE System and Recruiting Resource Planning

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A TECHNICAL REPORT
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Approved by
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Vita

Lieutenant Colonel David A. Thomas was born in Arkansas on June 1, 1953. He currently serves as an associate professor in the Department of Systems Engineering at the United States Military Academy, West Point, New York.

He received his undergraduate degree from the United States Military Academy in June 1975. Lieutenant Colonel Thomas earned his Master's degree in Operations Research at the United States Naval Postgraduate School, Monterey, California, in June 1984. He completed his Ph.D. in Management Science/Operations Research at the Graduate School of Business, The University of Texas at Austin, Austin, Texas, in August 1990.

Lieutenant Colonel Thomas has served in a variety of Army assignments, both stateside and abroad. These include leadership and staff positions in Air Defense Artillery units; operations research analyst positions on the general staff, United States Army Recruiting Command; and on the Army staff as a personnel policy analyst for the Deputy Chief of Staff for Personnel.

His research interests include optimization techniques for manpower planning, efficiency estimation techniques, exploratory data analysis, and statistics.

Acknowledgments

Several people have provided assistance and encourgement in the development of this report. I would like to thank Major Jim Thomas, Office of the Deputy Chief of Staff for Personnel, Headquarters, Department of the Army, Major John Hershberger, United States Army Recruiting Command and Lieutenant Colonel Charlie Darwin, Office of the Chief of Staff, Army, for their constant assistance and support in all phases of this effort. Also, a thank you to Dr. Abe Nelson, United States Army Research Institute, for serving as the torchbearer in promoting further use of the methodology developed.

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Executive Summary

This report details research and analysis efforts conducted to implement and improve the Forecasting and Allocating Army Recruiting Resources Study -- Sequential Hierarchical Allocation of Resource Elements (FAARRS-SHARE) system of models. The models were developed, beginning in 1990, to assist Army manpower planners in quantifying the impact of resource changes on recruiting, and concordantly, the impact of changes on recruiting levels on resource needs.

Personnel turmoil and changeover caused full-scale acceptance and implementation of the system, particularly at the Headquarters, Department of the Army level, to be delayed. This report documents an example of use and suggests areas for improvement.

The system of models appears to provide reasonable, real-time answers to questions regarding required resources to support different recruiting scenarios.

1. Purpose of Report

The purpose of this report is to provide information for Headquarters, Department of the Army (HQDA), the Army Research Institute (ARI), Headquarters, U.S. Army Recruiting Command (USAREC) users of the FAARRS-SHARE system of models to assess the impact of changes to the recruiting environment. The report presents a scenario where resource planners increase national advertising resources by 10 million dollars beginning in FY95 and demonstrates the use of the SHARE system to measure the impact of the increase on attainable accession levels. As an ancillary purpose, this report briefly presents documentation required for maintenance of the models for continued and increased use by HQDA, USAREC and ARI analysts and planners to rapidly assess recruiting policy changes.

2. Background

The All Volunteer Army experienced dramatic growth in resources from its inception in the seventies, through its first "successful" period at the end of the eighties. Those resources had their effect -- The overall "quality" of the recruit cohorts, as measured by high school diploma graduate status and by entrance examination scores, paralleled the growth in resources. In fact, in 1992, the Army attained quality goals once thought to be unattainable -- 100% of the recruits were high school diploma grads, and over 75% scored in the upper half of the entrance exam, and none scored in the lowest allowable test category. But as early as 1990, questions were being asked by Congress and others, like "how much is enough?" Manpower planners had quantitative tools that forecasted total annual new manpower (accessions) requirements, but the actual costs associated with recruiting that cohort were developed in an ad hoc, almost capricious manner by several different layers of command and staff at the Headquarters Department of the Army (HQDA) and the U.S. Army Recruiting Command (USAREC). Issues surrounding the highly successful Desert Shield/Desert Storm operations only added to the need for methodologies that could quantify the impact of resources on recruiting that ultimately lead to readiness of the force.

In late 1990, analysts (the author included) in the Office of the Deputy Chief of Staff for Personnel (ODCSPER) developed a plan to build a system of models that would allow both: forecasting accession levels attainable, given resource levels; and forecasting resource levels required, given an accession requirement. That plan resulted in contracted research by the Center for Cybernetic Studies (CCS)of the University of Texas at Austin. Dr. Abraham Charnes, one of the original operations researchers, directed the efforts of the CCS. Called the "Forecasting and Allocating Army Recruiting Resource Study", the research resulted in a new methodology based on calculations of relative unit (battalion) efficiency. The efficiency estimation method led to new methods for forecasting accession/resource levels at the Program Element level of detail for the seven years of the Program Objective Memorandum (POM) cycle. We named the methodology "Sequential Hierarchical Allocation of Resource Elements" (SHARE). We develop and discuss the theoretical underpinnings of the methodology in Charnes, *et al.* [1990] and in Charnes *et al.* [1993].

The team at CCS produced a prototype, usable software realization of the research in a *record seven months*.[Charnes *et al.* 1991] For the first time, analyst in both budget shops and accession planning shops at both HQDA and USAREC used a common platform to plan the POM beginning with FY92. The Deputy Chief of Staff for Personnel, then LTG Reno, the Director of Program Analysis and Evaluation, MG Stroup, and the commander USAREC, MG Wheeler, agreed that the methodology was worth further validation, so a

follow on effort began in late 1991 to "revise, calibrate, and validate" the system of models. Additionally, MG Wheeler requested that a similar methodology be explored and developed for Reserve Component accession planning. The Army Research Institute (ARI) took over management of the contract effort, and revised software and a technical report were delivered in November 1992. I assume the reader is familiar with the system as detailed in Charnes *et al.* [1992] for the remainder of this report.

3. Personnel Changeover and System Implementation

Unfortunately, analysts and policy makers at HQDA, USAREC and ARI do not use the SHARE system to full capability today. *All* key senior leaders involved in the development of the model transferred to other jobs. Analysts *at every level* transferred and in some cases were not replaced, or there was *no overlap* with replacements. USAREC headquarters relocated from Fort Sheridan, Illinois to Fort Knox, Kentucky with key civilian analysts opting to remain in the Chicago area. The few key users of the system experienced trouble updating the model with current data -- data that had been supplied by the transferred analysts mentioned above! And, the most damaging blow to the sustaining the effort came in December 1992 -- Dr. Charnes succumbed to cancer after a strong but all-too-brief battle.

The Department of Systems Engineering course notes Systems Simulation Course [1993] for an undergraduate course in modeling discusses the characteristics of a *good* model: A *good* model is

Needed
Simple and easy to understand
Robust
Adaptive and revolutionary
Well documented

I would argue that the SHARE model is a *good* model along all these attributes, perhaps one of the *best* produced in recent years for the manpower planning community. Documentation was provided that was sufficient at the time for the team that had developed the system of models and had used it. However, the unusual personnel turbulence mentioned above taxes even the best. As a member of the original team, I hope that the efforts detailed in this report will provide example that will foster renewed use of the SHARE system.

4. Base Year Issues

Using the SHARE system is described in detail in Charnes *et al.* [1992]. Analysts often discuss the "base year" associated with any model of recruitment activity, where historical data is used to develop estimates of the recruiting production function. In this system of models two "base years" are utilized in the development of the forecasts of interest.

4.1 The First Base Year

The first "base year" (a historical one) produces the *elasticities* that are used to develop the outyear forecasts for both resources and accession levels. These estimates rely on *FY89* and *FY90* data -- all prior to the build up required for Operation Desert Shield/Desert Storm. Additionally, the negative feelings associated with "war clouds on the horizon" perhaps had not yet affected the relative impact of advertising (national television, national radio, national print, and local advertising) on recruiting success. Contrary to the positive reasons for maintaining the use of these elasticities, resource levels for recruiting, especially national advertising, the number of on-production recruiters was higher in FY89 and early FY90 than the level we now experience under downsizing. In other words, because of the downsizing, we actually recruit more efficiently than the model system "sees" and calculates efficiency scores and hence relative rates of change for each recruiting resource. Is it proper, then, to use these years as "base years?" Policy makers and researchers must address this question as we continue to assess the impact of the Gulf War and of other dramatic policy changes. For this effort, I assume that the elasticities are in fact stable enough for demonstration purposes. See Charnes *et al.* [1991, 1992] for discussion of this stability.

4.2 The Second Base Year

The second "base-year" serves as the *start point* for determination of out-year forecasts. Additionally, inflation calculations rely on this base year for conversion to current dollar future estimates. The system of models currently uses FY91 as the base for forecasting FY92 as the "current year" and develops "program years" through FY98. The user's guide specifies procedures to update this base year -- but new data for FY92 has not been made available. Clearly, for more precise answers for each Program Element, particularly in the "Forecasting Resources" mode Charnes *et al.* [1992], HQDA policy analysts should correct this shortfall immediately. However, to demonstrate the use of the model, it is safe to proceed; *conservative estimates* are provided in forecasting production (accession) levels based on aggregate changes to overall resource levels.

5. Assessing the Impact of Advertising Resource Increase -- A Notional Example

Again assuming familiarity with the basic approach required to input data and to execute the SHARE (Version 2.4) system, consider the following examples where advertising resources are increased by $10 million, beginning in FY95. For best results the reader should operate the system while "working through" this example. First, forecast production levels attainable, by invoking the commands and entering the data as below. Review Charnes *et al.* [1992] for detailed discussions of the processes.

5.1 Forecasting Production Levels with the Increase

A "before and after" approach allows for assessing the impact of the advertising increase. First develop a base case with advertising levels prior to the proposed increase

1. Return to the DOS prompt if in Windows -- most computers do not have the requisite memory to run SHARE and Windows simultaneously. Change to the SHARE directory, or establish a "PATH" command to point to that directory.
2. Enter "SETPRINT" at the DOS prompt. Select the appropriate printer from the menu provided to establish the required printer drivers.

3. Enter "SHARE" to open the graphical user interface.
4. Move the cursor to the right to highlight the "Alternative" module.
5. Select "Modify Existing Alternative", and then highlight any one of the alternatives available.
6. Select "Forecasting Production" when prompted. The system then presents a menu of analyst controlled parameters:

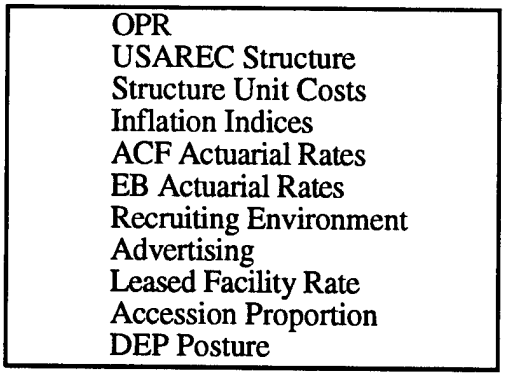

Figure 5.1 Forecasting Production Parameter Menu

It is imperative that the analyst highlight and review each set of spreadsheets that support each of these menu choices, as the SHARE calculations are sensitive to the data contained. The data stored in each spreadsheet for each Alternative depends on the most recent use of the model -- several examples of seemingly spurious forecasts from the model have been traced to use of the model with "unreasonable" parameters that were either stored from an earlier "run" of the model, or were originally developed from the data files supplied to the model during an update. To demonstrate this example, only the highlighted parameters are changed.

7. Highlight "OPR" and press enter. USAREC plans on 4200 OPR (on production recruiters), so beginning in FY93, and following for each year, highlight the year, press "F5" and enter 4200. Press escape and answer "Y" to save changes. Note that the analyst is returned to the parameter menu.

8. Highlight "Recruiting Environment" and press enter. For this example, we change only the estimates of unemployment. DOD recruiters and market estimates are currently under research by ARI; the values that are provided with the model reflect the most current. Using the same method as above (highlight, press "F5", enter new value, press "escape", then "Y" to save updates), enter the following estimates of unemployment as provided by ODCSPER in July 1993:

1993-PY1	1994-PY2	1995-PY3	1996-PY4	1997-PY5	1996-PY6	1999-PY7
7.1	6.7	6.3	6.0	5.8	5.7	5.7

Table 5.1 Unemployment Estimates

9. Highlight "Advertising" and press enter. For this example we work with an increase in dollars -- so highlight "Advertising Dollars." The data displayed (unless previously altered) reflects media time and space estimates as of late calendar year 1992:

Media	1993-PY1	1994-PY2	1995-PY3	1996-PY4	1997-PY5	1998-PY6	1999-PY7
Rd	5609554	5652343	5651504	5646470	5649826	5610393	5494611
Pr	5390280	5434920	5434920	5427480	5431200	5394000	5278680
TV	19566350	19717780	19717780	19701840	19709810	19574320	19159880

Table 5.2 Base Case Advertising Resources

For this example, make no changes at this point. Press "escape" to return to the menu.

10. Highlight "Accession Proportion" and press enter. Here review the quality constraints. For this example use the defaults provided. It should be noted that changes here could provide information on accession levels attainable with given changes to the quality goals mandated by HQDA. Press "escape" to return to the menu.

11. Highlight "DEP Posture" and press enter. As above use the default constraints; these have been provided by USAREC. Press "escape" to return to the menu.

12. Press "escape" and move the cursor to "Run Model." Highlight "Forecasting Production", then "Mode 5 OPR ADV $". The other modes are discussed in detail in [Charnes *et al.* 1992].

The system then begins the series of SHARE calculations.

13. Move the cursor to the right to "Report" and press enter. Select "Mode 4-6 Spreadsheet" and press enter. Select "Contracts" to view the output required.

14. On the spreadsheet, view "Net NPS Forecasts" for the accession levels attainable with the base case entered above. Both contracts and accessions are displayed, depending on the year under observation. Values estimated by the SHARE calculation for net NPS accessions are as follows:

1995-PY3	1996-PY4	1997-PY5	1998-PY6	1999-PY7
80,275	79,945	79,922	80,056	79,691

Table 5.3 Base Case Accessions Attainable

Record the numbers or press "F9" to print this spreadsheet. The base case established, only the advertising parameter needs to be changed -- the simplest means to assess the impact of the change is to use the same scenario generated above.

15. Press escape and move the cursor to "Alternative", press enter. Select "Modify Existing Alternative", press enter, and select the same alternative that was adjusted in the base case.

16. Review all the parameters again to ensure that the correct alternative has been selected. All the values for the various parameters changed and entered above are stored under this scenario. Highlight "Advertising", press enter, highlight "Advertising Dollars" and press enter.

17. For this example, we assume that the $10 million increase under investigation is applied to national TV advertising. Other excursions are possible, but for demonstration purposes, highlight "TV (Constant Dollars)", and using the "F5" key change the data for FY95 and beyond to reflect the $10 million increase by adding $10 million to each value from 1995 through 1999. Values for the media after the $10 million increase to TV (constant dollars) are as follows:

Media	1993-PY1	1994-PY2	1995-PY3	1996-PY4	1997-PY5	1998-PY6	1999-PY7
Rd	5609554	5652343	5651504	5646470	5649826	5610393	5494611
Pr	5390280	5434920	5434920	5427480	5431200	5394000	5278680
TV	19566350	19717780	29717780	29701840	29709810	29574320	29159880

Table 5.4 Adjusted Advertising Resources

Press escape and enter "Y" to save the changes.

18. Now move to the "Run Model" window, select mode 5, and execute the system. This execution runs the SHARE calculations with changes to TV advertising dollar amounts only. All other values should be the same as for the base case developed in steps 1-14 above. Returning to "Report", "Mode 4-6 Spreadsheet" and "Contracts" view the net contracts.

Comparing the base case values for net NPS accessions to the new values that reflect the estimated change associated with the $10 million increase, we see the following:

	1995-PY3	1996-PY4	1997-PY5	1998-PY6	1999-PY7
Before	80,275	79,945	79,922	80,056	79,691
After	87,311	86,956	86,930	87,114	86,838

Table 5.5 Comparison of Accession Levels Attainable

Calculation (off-line) of percent change due to the increase in advertising reveals an *approximate 8.8% increase across all years in accession levels with the $10 million increase in TV advertising.*

This, of course, is a conservative estimate at best. Recall the discussion above on the base year issues -- the data provided the model reflects media importance current in FY91. The accession levels reflect conservative DEP loss and market estimates that are due updating. Inclusion of the entire $10 million increase in the TV media agrees with current institutional knowledge that TV provides the most cost effective means on increasing awareness in the short term.

Similar model execution under the "Forecasting Resources" mode in which advertising dollar amounts *required* for 70K-75K accessions, with 54% GSMA, 67% I-IIIA, 85% male, 95% HSDG, (the current quality "marks" required by the DCSPER) were also run. Forecasts produced by the model reveal that an average of $41.2 million dollars of advertising (in aggregate) is required to maintain the accession levels. Base year inflation adjustments notwithstanding, a $10 million increase appears to be reasonable for "steady-state" accession levels.

6. Required Data Updates

The development of the SHARE system required coordination across several organizational layers -- at both HQDA and at USAREC. Accordingly, data updates are difficult at best. Compound the coordination required with the personnel turnover mentioned earlier, and we can easily violate the "rules for a good model" in short order. A coordination meeting should be established by the ODCSPER on at least a semiannual basis, where analysts from HQDA, ARI, and USAREC use the software to guide a data call for any required updates. Since the model provides both resource and policy estimates, both the Program Budget branch of the Manpower Directorate (DAPE-MBB), the Recruiting Policy branch, Military Personnel Management Directorate (DAPE-MPA), the Mission branch of USAREC Program Analysis and Evaluation Directorate, and appropriate Resource Management and Logistics Directorate personnel should participate. ARI researchers would provide necessary research on demographic and market trends. What follows is a brief overview to perhaps guide the update procedures and other associated data discussions.

There are two update processes available. The first is only performed at the end of a fiscal year, when new budget data are available. This update procedure, for changing the base year, as well as updating any of the original alternative values, is menu driven. To begin

the update procedure, select "View/Edit Data" from the SHARE menu, and then select "Change Base Year". The user is then offered the following choices:

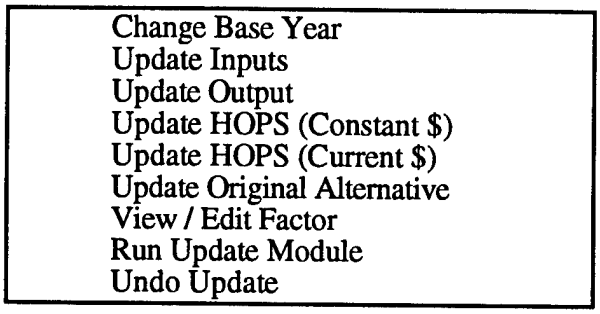

Figure 6.1 Changing Base Year Menu

Each selection must be updated in turn, and then the "Run Update Module" replaces all data tables in the model with new data. Financial data (e.g. HOPS data) should be jointly developed by the ODCSPER (DAPE-MBB) and USAREC. Some documentation is offered for each menu choice by pressing "F1" -- this feature was added so the user can add any information desired, such as the office that provides the required update.

The second update process occurs each time the user desires to exercise the model. Discussed earlier, each scenario requires that the user check each data element -- spurious results can occur when incorrect values are included in any scenario. The values for outyear parameters are changed by pressing "F5" in any window, and then by entering the new values, saving and escaping from the update window. Different parameters are available for update under the "Alternatives" and "Modify Existing Alternative" selection on the menu bar. Different parameters are displayed for both the "Forecasting Resources and Costs" and the "Forecasting Production" options. The user should become familiar with each data screen and read the "F1" Help screen for each -- adequate description is provided for most entries. A matrix for each of the parameters is provided below with the appropriate office responsible for the data.

Data Element	Agency Responsible for Update
Manpower Constraints	USAREC
USAREC Structure	USAREC
Structure Unit Costs	USAREC
Inflation Indices	DAPE-MBB
ACF Actuarial Rates	DAPE-MBB
EB Actuarial Rates	DAPE-MBB
Recruiting Environment	USAREC/DAPE-MPA/ARI
Advertising	USAREC/DAPE-MPA
Leased Facility rates	DAPE-MBB/USAREC
Accession Workload	DAPE-MPA/USAREC
DEP Posture	USAREC/DAPE-MPA

Table 6.1 Data Responsiblities for Forecasting Resources & Cost

As with the forecasting of resources and cost, forecasting production is carried out by a number of organizations (see Table 6.2)

Data Element	Agency Responsible for Update
On Production Recruiters	USAREC PAE
USAREC Structure	USAREC RML
Structure Unit Costs	USAREC RML
Inflation Indices	DAPE-MBB
ACF Actuarial Rates	DAPE-MBB
EB Actuarial Rates	DAPE-MBB
Recruiting Environment	USAREC/DAPE-MPA/ARI
Advertising	USAREC/DAPE-MPA
Leased Facility rates	DAPE-MBB/USAREC
Accession Proportion	DAPE-MPA/USAREC
DEP Posture	USAREC/DAPE-MPA

Table 6.2 Data Responsiblities for Forecasting Production

It cannot be emphasized enough that each model execution requires at least a check of all values in each spreadsheet. The data coordination meeting above could also be utilized to gain common agreement on default values for routine scenarios. Further recommend that routine updates be established and documented via memorandum from DAPE-MPA to USAREC Chief of Staff for appropriate dissemination and collection at each level. Memoranda with dates could then be referenced in the "F1" user supplied help screen for each data element.

7. Conclusions and Directions for Future Research

This report has demonstrated the use of the FAARRS-SHARE system, utilizing a very simple scenario. Utilizing the data that was provided with the November 1992 release of the software, and updates for on production recruiters, unemployment and other parameters, a base-case comparison method is used to demonstrate the change in accession levels attainable, given a change in advertising resources. Hopefully, this demonstration, coupled with the brief description of the coordination required for data updates will foster renewed use of the system.

Several recommendations for revisions and further research are also in order. Already mentioned above, the data coordination meetings are of prime importance. These coordination meetings should be logically extended into "FAARRS-SHARE User's Meetings" much like those held for other large scale manpower models and systems, such as for the REQUEST [See ref. 6] recruiting reservation system, and for the routine ELIM-COMPLIP [See ref. 7] forecasts.

Additionally, "ownership" of the model should be established. Originally developed jointly by budget analysts, policy analysts, and recruiting analysts, the proponent should be one that easily converses in all of these disciplines. This unifying effect should not be lost -- by using the same common platform, dialogue is fostered among the participants along the way. The proponency is necessary for coordination of model use and model maintenance. Perhaps an initial agenda for the first user's meeting is to establish which office will serve as the proponent.

Proponency established, further recommend that new research reassess the stability of the original elasticity estimates that drive the SHARE calculations. Additionally, this effort should include further documentation of the model. In all fairness, the CCS responded to the direction provided by HQDA, and required last-minute changes to the software as well

as analytical forays precluded requisite time for proper documentation. The relatively small costs associated with this effort would be exceeded by the benefits. The system of models is perfectly suited to the type questions our Army leadership will face as we continue to downsize.

Finally, recommend that formal training in the use of the model be instituted. Such training would be useful for analysts at HQDA, USAREC and ARI. Training curriculum could be developed jointly by the offices mentioned, and tailored to the policy and budget issues of the day.

In conclusion, the FAARS-SHARE system offers great promise in addressing the questions regarding recruiting policy and its effect as we shape the Army of the twenty-first century.

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[5] Modeling Handout, Systems Simulation Course, SE481, Department of Systems Engineering, U.S. Military Academy, July 1993.

[6] For information on the REQUEST, or Recruit Quota System, contact DAPE-MPA, at DSN 225-2225.

[7] For information on the ELIM-COMPLIP, or Enlisted Loss Inventory Model-Computation of Manpower Programs using Linear Programming, contact DAPE-MPA, at DSN 225-2225.