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Enhanced Forecasting and Allocation of Army Recruiting Resource Study (FAARRS-SHARE)

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This note describes the enhanced forecasting and allocation of Army Recruiting Resources study--sequential hierarchical allocation of resource elements (FAARRS-SHARE) methodology and extensions to it. The results of the calibration and validation of enhanced FAARRS-SHARE and preliminary investigation of the applicability of the system to the Army reserve are presented. Software enhancements are also described. Enhanced FAARRS-SHARE provides the ability to forecast, allocate, and evaluate Army recruiting resources needed for desired accessions. It also provides the capability to evaluate quickly the effects of suggested changes in a program or in resource availabilities. FAARRS-SHARE is based on innovative optimization techniques that provide "real time" responses to Army downsizing scenarios, including budget implications. The enhanced FAARRS-SHARE system employes a "semi-parametric" statistical method. Using Data Envelopment Analysis (DEA), an empirical frontier production function form of recruiting is estimated. Using this production function form, a total command annual leave multiplicative function form is estimated from battalion-level quarterly data. This form uses goal programming to be consistent with observed
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recruiting behavior. The elasticities implied in this production function are employed in optimization models to forecast contracts or resource levels.

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ENHANCED FORECASTING AND ALLOCATION OF ARMY RECRUITING RESOURCE
STUDY (FAARRS-SHARE)

CONTENTS

ENHANCED FORECASTING AND ALLOCATION OF ARMY RECRUITING RESOURCE STUDY (FAARS-SHARE)

INTRODUCTION

This report details extensions and refinements made to the Forecasting and Allocation of Army Recruiting Resources Study-Sequential Hierarchical Allocation of Resource Elements (FAARRS-SHARE) system and software originally presented in Charnes et al. [1]. The purpose of the original research (FAARRS-SHARE) was to develop a simple, rapid response methodology and accompanying software for forecasting, allocation and evaluation of annual Army recruiting resources at the aggregate HQDA level. Such a system was required in order to implement a multiyear program of desired accessions or to quickly evaluate effects within 72 hours of suggested changes in accessions or in resource availabilities across such a multiyear program. Successful completion of the initial research and development of software was achieved in six months, and the initial SHARE system has since been in practical use at both ODCSPER and USAREC. As a result of this usage, additional features and capabilities, not previously requested by ODCSPER, were recognized as desirable, and the potential for expanded application of the system (e.g., to the Reserve component of the Army) became apparent.

The second phase of the SHARE project, reported here, was to (1) research and implement a variety of requested modifications and improvements to the SHARE software; (2) provide a calibration and a validation for the models underlying the SHARE system; and (3) begin preliminary investigation of the applicability of the system for Army Reserve use.

This report is organized as follows. The next two sections provide a background for the project and an overview of the theoretical developments. Following sections discuss data issues and the impact of the changes in the recruiting battalion structure, present practical findings from the model validation and other research efforts, and provide a summary of the software extensions and refinements. Preliminary discussion of alternative use of the SHARE system in the context of the Army Reserve is provided in a summary section. The second part of this report describes the SHARE system in detail and also serves as a User's Manual. For completeness, and in order that the present report stand alone, relevant aspects from [1] have been summarized for inclusion here.

BACKGROUND

As discussed in [1], the Army battalion is the "lowest" management element that has direct control over primary resource decisions that lead to "production" of contracts for Army service. Moreover, since the current downsizing trend in Army strength requires forecasting across much lower accessions than in previous recruitment, better instruments needed to be developed that would be consistent with USAREC command and control recruitment management and not conflict with USAREC experience. Meeting these requirements made possible the new "multiplicative aggregation" method developed for FAARRS-SHARE that permits us not only to go from battalion to total command, but also from quarterly accessions to multiple quarters and to yearly accessions.

This research focused on developing the mathematical and statistical methodology from the high school diploma graduate (or senior expected to graduate) male I-IIIA, or Graduate Senior Male I-IIIA (GSMA), category of recruit. Apart from availability of data, this was

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motivated by the realization that about seventy percent of the total costs and almost all resource needs including the Army College Fund (ACF) and Enlistment Bonuses (EB) are operable for GSMA recruiting, and that simple known desired relations held with respect to the other Non Prior Service (NPS) categories regarding quality or sex.

The FAARRS-SHARE process employs a multiplicative Data Envelopment Analysis (DEA) model to (a) approximate a new variant of the successful recursive NEWS models (Charnes et al. [2]) for advertising and other effects on product sales; (b) determine the "most consistently best performing battalions (BNs);" and (c) achieve therefrom, by a constrained weighted least absolute value method ('goal enhancement'), the relative rates of change ('elasticities') in optimal (so-called 'technically efficient') performance of recruiting resource and environmental elements [3], [4].

The constraints in the goal enhancement require the elasticities to be consistent with write-rates, the NEWS recursion effects of Gross Rating Points (GRPs) needed by advertising policy and other observed or historically-known advertising or environmental factors. Without these (plus use of weighted least absolute values), the regression formula obtained from any form, multiplicative or otherwise, can be grossly erroneous. This occurred in the Wharton Center for Applied Research formulae of the Joint Advertising Mix Experiment (JAME) whose write-rates were grossly in error. Their results also exhibited the fallacy that Advertising would decrease enlistments.

Adjusting to a remark of COL Morsch of USAREC media planners that our product form for national advertising would result in zero enlistments for zero GRPs after new mathematics, we analyzed historical data to determine the minimum of "floor" amount of advertising that would correspond with historical contract production. Essentially this new enhancement was accomplished with the addition of 75 non-costed GRPs form each media type. With zero costed GRPs this would give correct historical results including that of pre-national advertising

Two interrelated optimization problems were also involved: (1) for determining maximum gross rating points (GRP) subject to advertising quality constraints on national media at given total media cost; and (2) for determining the minimum cost of achieving desired levels of net contracts, or equivalently, determining maximum net contracts for given On Production Recruiters (OPR) cost plus national media cost. These problems were solved explicitly thereby reducing least cost (or maximum output) considerations to only three items: (a) net contracts, (b) OPRs, and (c) total national media cost. A further analytical and computational convenience was in the use of managerial (or historical) policy for the proportion of OPR (or national media) cost to the sum of OPR and national media costs.

The DEA, the goal enhancement, and the optimizations thus described all are developed based on optimal (Pareto) efficiency. However, resource planning at the HQDA and USAREC level requires consideration of "inefficiencies" inherent to actual recruiting—although we retain the "optimal efficiency" estimates for useful managerial information. To ensure that resources are allocated to account for inefficiencies, the entire production function (and associated SHARE formula) is "adjusted to actuality" through a factor developed by comparing the number of OPRs at efficiency with the actual in a given year or historically. This factor, called the Actuality Adjustment Factor (AAF), then provides an empirical "shift" of resource estimates.

Although ACF and EB are important in expanding the market for quality contracts or filling certain Military Operation Specialty (MOS) specialities, they were not explicitly included in the inputs used. They are best treated mathematically as part of the recruiter's appeal or effectiveness since, once there is sufficient dollar resources for all those taking these incentives, no further increase in the total amount will bring in any new contracts. Instead, the

associated costs were estimated on the basis of historical proportions of those taking the incentives at the various battalions. For the urban battalions the proportions are very high; for the non-urban battalions they are about half the urban proportion.

This methodology further accounts for problems identified in [4] with mathematical statistics regression estimation problems

(1) specification -- wrong inputs or outputs or wrong possibilities of choice; here by more than ten years experience with USAREC data

(2) robustness of the criterion -- use of weighted least absolute value rather than the very sensitive least squares or maximum likelihood

(3) collinearity -- lack of independence of inputs or outputs; here the absolute value criterion plus constraints to insure valid specification minimized this problem from that of least squares or maximum likelihood.

The DEA-based microanalysis is a nonparametric methodology that requires no a priori model specification; the enhanced goal program and subsequent SHARE calculations involve analytical or parametric solutions -- hence we call this a "semi-parametric" method.

DEVELOPING FORECASTS: THE SHARE CALCULATIONS

This section draws in large part from the explicit development of the SHARE methodology.

Multiplicative Battalion and Temporal Aggregation

The Sequential Hierarchical Allocation of Resource Elements (SHARE) "production" (i.e. quality contracts) methodology moves from accessions to net contracts as "output," aggregates battalion "inputs" (recruiting resources and environmental elements) to total command "inputs," and aggregates quarterly inputs (outputs) to yearly inputs (outputs).

To develop national or command level quality contract estimates using a basic SHARE formula for optimal production in a particular time period with a particular number of battalions, an aggregate "production function" of the following form is developed.

$$(1) \qquad y = AP \prod_i x_i^{c_i}$$

The form (1) is obtained by aggregation from the individual

$$(1.1) \qquad y_j = A_j \prod_i \left(x_{ij}\right)^{c_i} , \text{ for each battalion } j, \ j = 1, \ ..., \ n, \text{ where } x_{ij} \text{ is the amount of}$$

input i in battalion j, A_j is its scale factor, and $y_j = p_j y$ is the to-be-achieved proportion p_j of the total command output y set by USAREC for battalion j.

Multiplying the battalion equations we obtain,

$$(2) \qquad \prod_j y_j = y^n \prod_j p_j = \prod_j \left[A_j \prod_i x_{ij}^{c_i}\right]$$

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Setting $x_{ij} = f_{ij} x_i$, so that

$$(2.1) \quad \prod_j x_{ij} = x_i^n \prod_j f_{ij}$$

we can solve for total command output y in the form of (1) where

$$(3) \quad A = \left[\prod_j A_j\right]^{\frac{1}{n}} , \quad P = \prod_i \left[\prod_j \left(p_j^{-1}\right) f_{ij}^{c_i}\right]^{\frac{1}{n}}$$

are products of <u>geometric means</u> of battalion factors and proportions.

Similarly, if total quarterly output is $y(Q) = p(Q)y$, quarterly input is $x_i(Q) = p_i(Q)x_i$, and quarterly $c_i = c_i(Q)$, then for an m-quarter aggregation we start with

$$(4) \quad p(Q)y = AP \prod_i x_{i(Q)}^{c_i(Q)}$$

so that

$$(4.1) \quad \left[\prod_Q p(Q)\right]y^m = [AP]^m \prod_i \left[\prod_Q x_i(Q)^{c_i(Q)}\right]$$

Since $x_i(Q) = p_i(Q) x_i$

$$\prod_Q x_i(Q)^{c_i(Q)} = \prod_Q p_i(Q) \prod_Q x_i^{c_i(Q)}$$

$$\doteq \prod_Q p_i(Q) \, x_i^{m \, \bar{c}_i}$$

where $\bar{c}_i = \dfrac{\sum_Q c_i(Q)}{m}$.

Solving for the m-quarter y, we have

$$(5) \quad y = A \bar{P} \prod_i x_i^{\bar{c}_i}$$

in precisely the form of (1) where

$$\bar{P} = \left[\prod_Q p^{-1}(Q)\right]^{\frac{1}{m}} P\left[\prod_Q p_i(Q)\right]^{\frac{1}{m}}$$

Temporal And Least Cost Share Simplification

Previous research (over years and through the JAME experiment) with USAREC had determined that lagged advertising (and other) effects from past advertising policies should be

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amply comprehended in quarterly data. Accordingly, basic DEA portion of the analysis utilized quarterly battalion data, from the second quarter of 1989 through the fourth quarter of 1990, and its aggregations. The DEA work determined in each DEA analysis the "robustly efficient" (r.e.) battalions, i.e., the most consistently rated high performing ones. The $\bar{c}_i$'s were then determined from the r.e. battalions' input-output values by "goal enhancement," i.e., using a weighted least absolute value objective subject to experiential constraints, e.g., on write-rates and other known factors whose range of effects were expressed by linear inequalities.

It was found that almost the same battalions emerged as r.e.'s in the various DEAs and further that the quarterly c_i's and most importantly the $\bar{c}_i$'s determined from these battalions in the three-quarter '89 and four-quarter '90 aggregations were unchanged. Thus they reasonably were employed across the eight year horizon for forecasting and allocation, and it was anticipated that no additional new DEAs would be needed for at least two years except in case of most unusual changes in the recruiting ambience.

Desert Shield/Desert Storm, along with the dramatic changes in recruitment brought about by "downsizing" of the Army, prompted additional DEA runs conducted under phase two of the SHARE project which confirmed the general nature of these findings. Even with significant changes to the recruiting battalion structure, there was a considerable degree of overlap between the r.e. set of battalions in the different cases.

Employing the initial notation of (1), denoting the current year quantities by 1 and the next year's by 2, applying formula (1) and dividing, we obtained for the yearly data

$$(6) \qquad \frac{y_2}{y_1} = \frac{A_2}{A_1} \frac{P_2}{P_1} \prod_i \left(\frac{x_{i2}}{x_{i1}}\right)^{c_i}$$

Herein the number of battalions in the two years may have been different.

For consistency between year 1 and year 2, with optimal (i.e., "technically efficient") production we should have been able to attain output level y_1, using the same levels of resources, under either battalion structure, so that

$$y_1 = A_2 P_2 \prod_i (x_{i1})^{c_i}$$

But $\quad y_1 = A_1 P_1 \prod_i (x_{i1})^{c_i}$, so

$$(6.1) \qquad A_2 P_2 = A_1 P_1.$$

and

$$(7) \qquad \frac{y_2}{y_1} = \prod_i \left(\frac{x_{i2}}{x_{i1}}\right)^{c_i}$$

without involving scale and proportionalities factors. Thus, SHARE year-to-year transitions required no estimation of scale and proportionality factors. Further, with known (constant factor) relation between year 1 and year 2, y_2 and y_1 in this ratio could be replaced by actual values.

Reduction to OPR and National Media Costs

With a SHARE formula

$$y = B \prod_i x_i^{c_i}$$

where B contains both scale, proportionality and environmental (non-discretionary variable) factors and the variable x_i's have total cost $d = \sum_i a_i x_i$, the Kuhn-Tucker theorem of mathematical programming uniquely specifies the optimal values x_i^* for maximum output y from total variable cost d or, equivalently, for least cost d for specified y as follows

$$(8) \quad x_i^* = \frac{d}{a_i} \frac{c_i}{\sum_k c_k}$$

The uniqueness of variable least cost resource elements for prescribed total variable cost with a production function of FAARRS-SHARE type allows the mathematical problem to be reduced to a relation between output and only two variables, OPRs and national media cost, or, alternatively, to total variable ("driver") cost and the OPR cost proportion of it. The best return from national media advertising is determined by maximizing the total GRPs obtainable from possible media mixes which satisfy the quality constraints policy of the Army's advertising agency at given total national media cost.

Let

$$x_i = \text{media i GRPs}$$

$$a_i = \text{media i GRP cost per point}$$

$$d_A = \text{total media cost}$$

where $i = 1, 2, 3$ corresponds respectively to TV, radio and print, and $a_1 > a_3 > a_2$. The quality constraints in cost terms were determined to be

$$.63 \leq a_1 x_1 \leq .73$$

$$.13 \leq a_i x_i \leq .18 \ , \ i = 2, 3$$

$$a_2 x_2 \leq a_3 x_3$$

With $\sum_i a_i x_i = d_A$, we wish to maximize total $GRP = \sum_i x_i$. This is a simple "knapsack" problem with unique solution

$$x_1^* = \frac{.64 \, d_A}{a_1} \ , \ x_i^* = \frac{.18 \, d_A}{a_1} \ , \ i = 2, 3$$

when $a_2, a_3 \leq a_1$.

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Thus, employing this solution and the minimum cost solution involving OPRs, the part of the SHARE formula containing only OPRs and national media GRP inputs (the so-designated "driver" variables) can be rewritten in terms of total "driver cost" d and d_A. Or further, with OPR cost as the proportion zd (and $d_A = (1 - z) d$) in terms of managerially prescribed (or historically employed) z and d above, the SHARE formula becomes

$$(9) \qquad y = B \prod_i \left(\frac{g_i}{a_i}\right)^{c_i} x_o^{c_o} d_A^{c_g}$$

In (9), B contains the environmental ("non-driver") inputs, $x_i^* = g_i \frac{d_A}{a_i}$, g_i the media fraction of d_A cost for medium i, $i = 1, 2, 3$, $x_o = $ OPRs, $c_o = $ OPR elasticity, and $c_g = \sum_i c_i$ is the sum of national media elasticities. With $z = $ OPR proportion of total driver cost d, the SHARE formula is then given by

$$(10) \qquad y = B \prod_i \left(\frac{g_i}{a_i}\right)^{c_i} z^{c_o} (1 - z)^{c_g} d^{c_o + c_g}$$

The optimal value for z is $z^* = \frac{c_o}{c_o + c_g} \approx 0.75$. Interestingly, the z's actually employed historically have been in the range of 0.78 to 0.84.

In using the SHARE ratios for transitions, the environmental or nondriver input factors may not cancel, nor may factors such as the $\left(\frac{g_i}{a_i}\right)^{c_i}$ or the z-factors which can differ from year to year.

From past joint work with USAREC, the environmental or nondriver inputs used in the FAARRS-SHARE model were:

Unemployment rate

Other DoD services recruiters (complement)

Local advertising dollars

Population of 17-21 year olds

THE ENHANCED SHARE SOFTWARE

The enhanced SHARE software provided to HQDA forecasts and allocates recruiting resources via the new ratio formulas described above, together with simple correlations for associated costs such as ACF, EB and communication costs, plus managerially specified recruiter support costs and advertising sustainment costs.

SHARE forecasts under three modes in each of two directions. In one direction, starting with base year data, the given desired accessions are converted into GSMA net contracts via Delayed Entry Program (DEP) experience and policy. Then, SHARE forecasts by year the needed OPR, national media GRP and all associated costs. The three modes are as follows:

Mode 2 - Constrained forecasting of resources and associated costs under a fixed number of recruiters;

Mode 3 - Constrained forecasting of resources and associated costs with an upper bound on total national advertising media costs.

The forecasted costs are displayed, together with the corresponding values for all relevant program elements (PEs) in addition to the three specific PEs for SHARE forecasting. Displays are given both in constant and in current dollars. All can be printed instantly with standard PC peripherals.

In the reverse direction, with specified OPRs or national advertising media cost, the accessions can be forecast. The three modes are as follows:

Mode 4 - Forecasting production using OPRs and national media GRPs;

Mode 5 - Forecasting production using OPRs, national advertising media dollars, and media GRP costs per point;

Mode 6 - Forecasting production by OPRs, national advertising media proportion of cost, media mix rates, GRP costs per point, and enlistment pay.

As before, all the PE data above is developed, displayed and can be printed instantly. Up to five additional alternative planning scenarios can be handled by the software.

Several other important features have been provided in the enhanced SHARE system.

- An on-line Help function has been included. When the user is developing alternative scenarios, SHARE provides a help screen for every type of data cell. Text in the Help window can be created and modified by the user so as to include any information about that data cell that is considered important, e.g., source of the data item, frequency of collection, etc.

- A built-in calculator has been attached to the Accession Workload Input. This allows the user to specify NPS accessions and then to adjust category proportions as required to meet mission requirements.

- A window has been provided for checking on the feasibility of alternative scenarios, that is, on the compatibility of user specified bounds on inputs with prescribed levels of output. When running an alternative to achieve a desired level of production, the forecasted number of recruiters or national advertising driver costs may fall outside the range of desirable or acceptable values. In which case SHARE gives a warning message in a special window, showing the user specified input bounds and the forecasted results for the years which are out of range. It also suggests that the user change corresponding input data or adjust the bounds and re-run the model. The originally forecasted results, however, may still be viewed via the report capability.

- Two-dimensional graphical representations of the production function have been added. The two graphics are: GSMA contracts as a function of the number of recruiters, and GSMA contracts as a function of national advertising media driver costs.

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Several cosmetic changes were also made.

- Displays of calculated manpower resources and associated costs were altered to conform with other HQDA reports.

- Separate inflation indices for the radio and print media were included.

- The DEP-Loss rate was divided into two categories: GSMA and Others.

- Descriptive information for each alternative recruiting scenario has been added to all printed reports.

- A dialog window has been added to the spreadsheet editor which queries the user whether modifications should be saved.

DATA ISSUES

The original FAARRS-SHARE DEA runs were based on quarterly data from the second quarter of 1989 through the fourth quarter of 1990 (seven quarters). In the second phase of the SHARE project additional data were provided, but these were not without their attendant difficulties, in part due to the changes that occurred in the recruiting battalion structure.

The new data sets included: number of OPRs, GSMAs, national advertising (Radio, Print, TV/Cable) GRPs, unemployment rates, and direct mail pieces and leads. Each set of data came in a different form and required different processing as outlined below.

OPRs

The data for number of OPRs were sent by FAX. We selected only LAS (Assigned RA Limited Production Station Commander) and ASG (Assigned RA Station Recruiters) from each quarter of 1992. The number of LASs and ASGs were summed to obtain an aggregate number of OPRs.

Difficulties arose with changes in the battalion structure over time. The data for FY 1991 were first provided in a 55 battalion structure. Then the number of BNs was reduced to 47 in July 1991 and finally brought down to 42 in July 1992.

We intended to conduct the DEA analysis with 1991 data using the 42 battalion structure so that it would be consistent with other data sets. However, the only OPR data available under this structure were for the 4th quarter FY 1992.

The total number of OPRs in 1992 was approximately 5180, 5130, 5010, and 4338 for quarters 1, 2, 3, and 4, respectively, where the data of the first 3 quarters were for 47 BNs and those of the 4th quarter were for 42 BNs. The data of the first 3 quarters were used to approximate the corresponding 3 quarters of 1991. The number of OPRs in the 4th quarter 1991 was determined by inflating by 10% the number of OPRs in the corresponding quarter of 1992, bringing it up to 4772 (from 4338).

There were 5 BNs which had to be merged with other BNs and this was accomplished in the following manner.

	Newburgh -1H	->	Albany-1A.
2/3	Richmond-3K	->	Paltimore-1B.
1/3	Richmond-3K	->	Raleigh-1J.
2/3	Cincinnati-5B	->	Columbus-3P.
1/3	Cincinnati-5B	->	Nashville-3I.
	Detroit-5F	->	Lansing-3S.
	San Francisco-6A	->	Sacramento-6I

GSMA

The data files containing the number of GSMAs are called 1STQTR.TXT, 2NDQTR.TXT, 3RDQTR.TXT, and 4THQTR.TXT, corresponding to the four quarters of the year. These files were loaded from the Univac mainframe computer at USAREC by USAREC staff. The data were in the 42 BN structure. Each file contains data relevant to a particular quarter for all 42 BNs for FY 1989, 1990, 1991, and 1992. The components of data were SMA, GMA, SMB, GMB, SM4, GM4, HMA, NMA, SFA, GFA, SFB, GFB, PA, PB, PS, SM, GM, NM, NPM, GF, GSA.

The numbers for GSMA net contracts used in the DEA analysis were obtained by summing the number of SMAs and GMAs for each BN. However, in some cases the number of SMAs was negative. In the absence of any other information, this negative number was interpreted as the number of contracts signed in the previous quarter but "lost" in the current quarter. Hence, the number of contracts in the previous quarter was reduced by this amount.

Nonetheless, the difficulty arising from this interpretation of a negative SMA value still remains. Suppose there is some loss of SMA contracts in a particular quarter but of an amount smaller than the number of SMA contracts written in that quarter. The net result would be recorded as a positive value for SMA contracts, and there is no way to know from this figure how many SMA contracts actually were lost. Fortunately, the absolute values of negative SMA contracts were usually small, so we have reason to believe that the loss is also small.

Unemployment Rates

The data file containing unemployment rates is a Lotus 1-2-3 file called UNEMPLOY.WK3. There are 3 types of data in this file: unemployment rate, number of quality contracts, and number of total contracts. The data were organized by the 8 quarters of FY 1990 and FY 1991 and by the 42 BN structure. The unemployment rates from this data file were multiplied by 100 to bring them to a percentage basis before they were used in the DEA analysis.

National Advertising GRPs

The files containing national advertising data were created using Symphony software. These files were JAS90.WR1, OND90ATL.WR1, JFM91ATL.WR1, AMJ91ATL.WR1,

JAS91ATL.WR1, 3QJAS91.WR1, OND91.WR1, TRACKAT.WR1, TRACKAT2.WR1. Each file could be read by DBASE IV software by changing file suffix from "WR1" to "WK1". The file names are abbreviations for the months and years to which they correspond. Hence, these files contained data for the 4th quarter of FY 1990, all 4 quarters of FY 1991, and the 1st quarter of FY 1992.

Each file contained data on population (18-24 year old market), TV GRPs, Cable GRPs, Broadcast GRPs, Magazine GRPs, Radio GRPs and Total Buy. The Broadcast GRPs are essentially the sum of TV GRPs and Cable GRPs. The data needed for the DEA analysis were Radio GRPs, Magazine GRPs, and Broadcast GRPs (which we loosely called "TV GRPs"). However, the data were organized by Area of Dominant Influence (ADI), not corresponding to any BN structure.

Again, a problem in data aggregation structure arose here. Some relation between ADI structure and the BN structure needed to be developed. The more elementary unit on which the two structures rested was county (FIP). Although crosswalks from ADI to FIP and from FIP to BN were available, they were still not enough since we had no information as to how the GRPs within an ADI could be divided up and redistributed to the relevant BNs. Two methods were developed as follows.

Method 1: All GRPs in an ADI were assigned to the BN with the largest overlapping area with that ADI. In other words, this BN was defined as the BN containing the largest number of FIPs from that ADI. This method yielded only 38 BNs to which GRPs would be assigned. The missing 4 BNs were those which always shared ADIs with other larger BNs and thus were never assigned any GRPs.

Method 2: The GRPs for each ADI_j were split into n_j equal amounts, where n_j was the number of FIPs in ADI_j. Thus, each FIP in ADI_j was assigned an equal proportion of that ADI's GRPs. The GRPs for any BN were constructed by summing up GRPs over all the FIPs which overlap this BN. This approach yielded a 42 BN structure.

Direct Mail Leads

The data files containing the number of direct mailings and leads were constructed using DBASE IV software. The number of mailings and leads in FY 1989 and 1990, organized by ZIP code, were delivered and subsequently aggregated to BN level using the cross-walk from ZIP to BN.

Population

Population data were available in two locations. Data on the 18-24 year old population were contained in the file with national advertising data, and were used in the GRP calculations. The OPR data file (92 quarter 4) contained data on the male 17-21 year old and female 17-21 year old populations for the 4th quarter FY 1992.

PRACTICAL FINDINGS

Model Validation

An important task specified for the Enhanced SHARE-FAARRS project was to validate the model using actual FY89 data. Since not all the necessary data items were made available for FY89, it was decided to execute the validation effort with FY90 actual data. Using 1991 as

the Base year, the actual 1990 accession data was entered into the model as the first outyear (replacing 1992 data) and resources were forecasted for these target outputs. This exercise was repeated with several AAF (Actuality Adjustment Factor) values and the results are shown below:

Data (AAF=1.08)	1991-Baseyear	1990-Actual	1990-Forecast
GSMA accessions	45063	42997	
% GSA complete	45	39.1	
GSMA entry DEP	23483	15373	
GSMA netcontracts	45177	55373	46699
no. of OPRs	4810	5401	4927
Radio GRPs	3270	4711	3893
Print GRPs	839	1312	1062
TV GRPs	1866	2838	2442
OPR's salary	27827	27258	
Radio $/point	839	1612	
Print $/point	3720	5909	
TV $/point	7970	9135	
Radio mix rate	18	18	
Print mix rate	18	18	
TV mix rate	64	64	
Local Ad.	1287000	6750943	
DOD recruiters	7849	8110	
Unemployment	6.7	5.9	
Prime Market	8944000	9281000	
Ad. proportion	0.134	0.219	

Clearly, the model predicted smaller amounts of resources than the ones which were actually consumed in 1990. In further attempts to calibrate the model, it was found that an AAF value of 1.18 brings about a much better match on the forecasted resources (i.e., the corresponding no. of OPRS is 5384). Thus, we come to the conclusion that 1990 was a highly inefficient year in comparison to 1991. The drastic 'improvement' in the recruiting performance in 1991 can be traced back to the effects of the Gulf war and to the steady increase in unemployemnt rates. The significance of these issues is discussed further in the summary section of this document.

Issues of Contract Quality

Here we make note of new procedures we developed for handling some potentially important issues concerning quality in projected contract attainment, and the associated costs, under recruiting environment conditions that were difficult to predict with any confidence or were unprecedented in recent recruiting history.

The main focus here is upon reestimation of driver cost and the number of efficient OPRs when achieved quality marks differ from target quality marks and the base year is to be updated. One way to proceed is to re-run the model with the actually achieved quality marks as the new target quality marks. An alternative procedure is described below.

(i) Driver cost forecast for the next base year

Let d_j be the total driver cost of year j, where $j=1$ for the current base year and $j=2$ for the next base year. By using the (known) actual values, d_2 can be forecast by the FAARRS-SHARE formula.

$$d_2 = d_1 \left(\frac{A_2 y_2 \prod_{i=1}^{3}\left(\frac{g_{i1}}{a_{i1}}\right)^{c_i} (z_1 a_{02})^{c_0} (1-z_1)^{c_s} (\overline{DoD})_1^{c_{DoD}} (Un)_1^{c_{Un}} (Lmps)_1^{c_{Lmps}} (Pop)_1^{c_s}}{A_1 y_1 \prod_{i=1}^{3}\left(\frac{g_{i2}}{a_{i2}}\right)^{c_i} (z_2 a_{01})^{c_0} (1-z_2)^{c_s} (\overline{DoD})_2^{c_{DoD}} (Un)_2^{c_{Un}} (Lmps)_2^{c_{Lmps}} (Pop)_2^{c_s}} \right)^{\frac{1}{c_0+c_s}}$$

(1)

where, as before,

c_0 = elasticity of number of OPRs,

c_1 = elasticity of radio GRP,

c_2 = elasticity of print GRP,

c_3 = elasticity of TV GRP,

and $c_g = c_1+c_2+c_3$.

(ii) Change in forecasted driver cost resulting from quality change

Let y_2 be the actual number of GSMA net contracts for year 2. Let the quality marks be represented in terms of % of I-IIIAs from NPSs. Let (%I-IIIA) be the actual quality mark achieved and (%I-IIIA)' be the target level. The ratio of the two can be expressed in terms of the number of GSMA net contracts as follows:

$$(2) \quad \frac{(\% \, I - IIIA \,)'}{(\% I - IIIA \,)} = \frac{\frac{y'_2}{NPS}}{\frac{y_2}{NPS}}.$$

where NPS' = NPS since they refer to the same year.

Thus

$$(3) \quad \frac{(\% \, I - IIIA \,)'}{(\% I - IIIA \,)} = \frac{y'_2}{y_2}.$$

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Using the FAARRS-SHARE formula the ratio of production levels y'_2 / y_2 can also be expressed as follows.

$$\frac{y'_2}{y_2} = \frac{A' \prod_{i=1}^{3} \left(\frac{g'_{i2}(1-z'_2)d'_2}{a'_{i2}} \right)^{c_i} \left(\frac{z'_2 d'_2}{a'_{o2}} \right)^{c_o} (\overline{DoD'})_2^{c_D} (Un')_2^{c_U} (Lmps')_2^{c_L} (Pop')_2^{c_s}}{A \prod_{i=1}^{3} \left(\frac{g_{i2}(1-z_2)d_2}{a_{i2}} \right)^{c_i} \left(\frac{z_2 d_2}{a_{o2}} \right)^{c_o} (\overline{DoD})_2^{c_D} (Un)_2^{c_U} (Lmps)_2^{c_L} (Pop)_2^{c_s}}$$

(4)

where A and A' are the scaling factors.

Since all quantities on the right hand side are the same except for the driver costs, the ratio becomes

(5) $\dfrac{y'_2}{y_2} = \left(\dfrac{d'_2}{d_2} \right)^{c_o + c_s}$.

So target driver cost d'_2 can be solved for as

(6) $d'_2 = d_2 \left(\dfrac{y'_2}{y_2} \right)^{\frac{1}{c_o + c_s}}$.

Since the inefficiency factor is the same in achieving y'_2 and y_2 and therefore cancels in the ratio, d'_2 is the cost estimate for the efficient drivers. The corresponding number of OPRs, x'_{o2}, is

$x'_{o2} = \dfrac{z_2 d'_2}{a_{o2}}$, where a_{o2} is the OPR salary of the new base year.

The corresponding advertising driver cost is $d'_{a2} = d'_2 - a_{o2} x'_{o2}$. From these and the inefficiency factor AAF, the estimate of <u>on-target</u> OPR cost and advertising cost can be made. This information is useful for USAREC and advertising operations guidance as well as for HQDA in exhibiting the implications of changes in quality targets or achievement.

Software Implementation

QMK.C is the code used for calculating the total driver cost, national media advertising cost, and number of OPRs when target quality differs from achieved quality. The code first reads actual data of the current base year and that of the next base year. Then it forecasts the total driver cost of the next base year by the FAARRS-SHARE formula. This forecasted total driver cost is based on the actually achieved quality. The second step is to further adjust the forecasted driver cost by a factor which is calculated on the basis of the difference between the achieved quality mark and the target quality mark. The corresponding number of OPRs and advertising cost is then calculated and reported.

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(i) Read data

The current base year data are read from the first columns of data files "*.@@@", i.e., the set of files which have suffix "@@@". The next base year data are read from the first columns of data files "*.UPD", i.e., the set of files which have suffix "UPD". The data files which are involved in this step are those which contain OPR salaries, advertising costs-per-point, media mixes, local advertising costs, DoD recruiters, unemployment rates, and populations.

The driver inputs, such as number of OPRs and national GRPs, for the current base year are read from the INPUT.DAT data file and those for the next base year are read from the INPUT.UPD data file. The number of GSMA net contracts for the current base year is read from the OUTPUT.DAT data file, and that for the next base year is read from the OUTPUT.UPD data file. Elasticities are read from the CI.DAT data file.

(ii) Driver cost forecast for next base year

After the data are read the code first calculates the proportion (z_j) of OPR cost in total driver cost for each of the two years as follows.

For each year j, let ai[] be the array containing driver cost where,

ai[0] = OPR salary,

ai[1] = radio cost per point,

ai[2] = print cost per point,

ai[3] = TV cost per point.

And let dr[ ] be the array containing the drivers where,

dr[0] = number of OPRs,

dr[1] = radio GRP,

dr[2] = print GRP,

dr[3] = TV GRP.

Let TD = actual total driver cost of year j, where

TD = ai[0]*dr[0]+ai[1]*dr[1]+ai[2]*dr[2]+ai[3]*dr[3].

Then z_j = ai[0]*dr[0] / TD, where ai[0]*dr[0], TD are for year j.

z_j is calculated for each year. z_j for the current base year is stored in the variable "z1" and that for the next base year is kept in variable "z2".

The total efficient driver cost for the next base year is forecasted by FAARRS-SHARE formula (1). This forecasted driver cost is stored in the variable "d2".

The details of step-by-step calculation for this part are similar to those given in "Forecasting of Number of Recruiters and GRPs" and will not be repeated here.

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(iii) <u>Change in forecasted driver cost resulting from quality change</u>

Let **"qmark1"** be the variable representing the target level of %I-IIIA and let **"qmark2"** be the variable representing the %I-IIIA which is actually achieved. "qmark1" is read from the WORKLUAD.@@@ data file and "qmark2" is read from the WORKLOAD.UPD data file.

Let **"qmk"** be the variable denoting the factor to be used in ascertaining the change in driver cost due to the change in the quality mark. By the equations in (3) and (6) we have

$$qmk = (qmark1/qmark2)^{1/c}, \text{ where}$$

c is the summation of the elasticities of all drivers.

Let **"d2prime"** be the on-target forecasted driver cost. Then

$$d2prime = d2 * qmk.$$

The corresponding number of efficient OPRs is computed by

$$OPR2\_prime = z2 * d2prime / OPR \text{ salary.}$$

The corresponding advertising driver cost is

$$da2\_prime = d2prime * (1-z2).$$

The results are reported in the QMK.OUT file.

Potential Application to Army Reserve

The methods and procedures developed in FAARRS-SHARE potentially have wider applicability than just to the Active Component (AC). As part of the current project we began initial investigations of what would likely be involved in extending the methodology to USAR recruiting. Here we sought to identify general data requirements, determine data availability and integrity, and familiarize ourselves with the special characteristics and nuances of USAR recruiting which could become problem areas. We can summarize our findings as follows.

Generally, the same kinds of core resources are required to secure quality Reserve recruits as are for AC recruits, but their differential effects may be quite different in the two cases. Moreover, we can expect additional factors, not so relevant in the AC case, to have an impact in the Reserve situation. For example, the role of civilian pay in the market will need to be examined closely, and the issue of market proximity to USAR centers will have to be explored.

Other issues further complicate matters. Several DEA analyses would likely be necessary in order to determine whether the AC (and perhaps the National Guard) should be treated as competition in Reserve recruiting. Competition from the other reserve components is also an important consideration, but what little information there is on competitive activity is of poor quality. For example, the presence and extent of competitive activity at the battalion level is unknown, and it is unclear whether the other service reserve components can provide that information.

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Many of the OMA dollars spent on automation, communications, the DEP, facilities, vehicles, advertising, etc. also support the USAR, so developing an appropriate allocation of cost in each funding area will be a major factor.

SUMMARY

We have presented detailed DEVELOPMENTS of our Enhanced FAARRS-SHARE system whose project objectives were

- Calibrate and validate FAARRS-SHARE model
- Revise FAARRS-SHARE software
- Preliminary research on USAR production function and USAR SHARE

The report details also includes a manual for operation of the Enhanced FAARRS-SHARE system.

The major advantage of this implemented methodology is its ability to present in a few minutes the cost detail over an 8 year horizon in all the 16 PE elements needed so as to assist in determination of both short and long run recruitment management policy.

In particular, the Enhanced system provides for immediate determination of the cost trade-offs with varying mixes of levels of quality, e.g., proportions of I - III As versus CAT 4's, etc., in GSMAs and NPS. Such quantitative determinations provide more informed assessments of the perils from frequent or extreme quality changes. Also studied, with the limited data available Direct Mail was shown to have a positive effect but of a marginal magnitude and to be dependent on other factors.

In regard to Reserve recruitment, as noted in our detail, our instrument showed by a "backtracking" that a smaller number of OPRs than on board should have been sufficient for Active recruitment in 1991. (USAREC did recognize this at the time. Their action of use of this excess in exploration (in a few battalions with top priority to Reserve recruitment) gives a further confirmation of the enhanced FAARRS - SHARE system's ability to achieve reasonable estimates of recruitment statuses for "What-If" analyses.)

This confirmation validates the idea that our methodology can be successfully adapted for Reserve applications. From our preliminary study we find the challenges to be met to be arising from

- No prior research
- Additional dimensions of complexity

  - Overlap of resources with regular recruiting
  - Mismatch in unit boundaries

- Poor (or no) data from other services

From past experience we conclude that difficulties of these types can be overcome with a team including active participation by knowledgeable officers responsible for Reserve recruitment activities.

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APPENDIX A

USER'S MANUAL

for

ENHANCED FAARRS-SHARE SYSTEM

SHARE SOFTWARE OVERVIEW

The enhanced SHARE software, Version 2.5, provides the current implementation (72 hours) of the FAARRS-SHARE methodology as a convenient instrument on a personal computer for Headquarters Department of Army (HQDA) to forecast and allocate Army recruiting resource elements.

SHARE SOFTWARE STRUCTURE

SHARE was developed in the C Programming language. It contains a colorful, user-friendly interface with multi-level menu operation . All data are shown on spreadsheets. The opening screen is shown below


```
Sequential Hierarchical Allocation of Resource Elements
              Enhanced Version 2.4
            Released: October 31, 1992
```
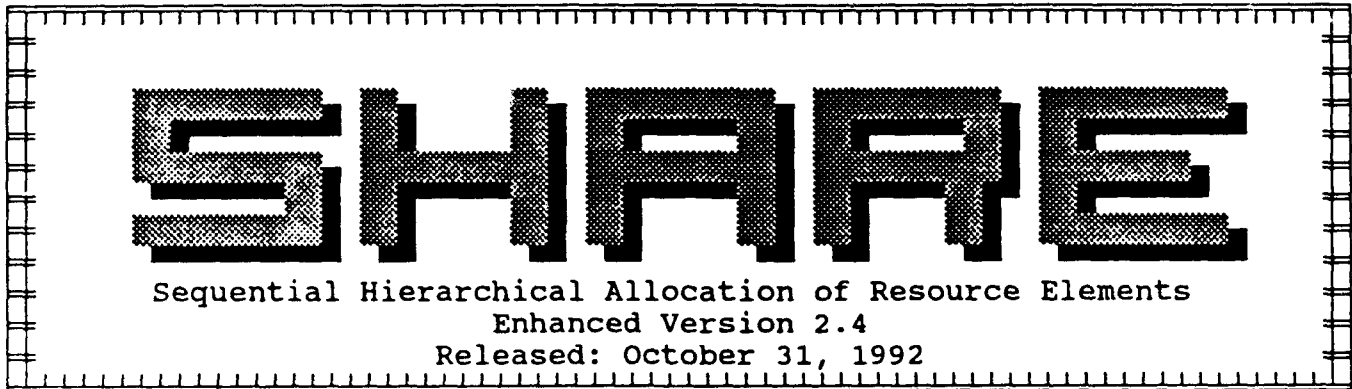
```
        (c) Copyright  1991, 1992
        Center for Cybernetic Studies
     The University of Texas at Austin
            All rights Reserved
```

```
Any Key to Continue . . .
```

plus a bottom-line summary sheet at least cost.

FAARRS - SHARE Model
Total Cost (Constant Dollars)

Alternative: 1
Running mode: Mode 1
Running time: Fri Dec 04 14:14:24 1992

	1991-BASE_YR	1992-CY1	1993-PY1	1994-PY2	1995-PY3	1996-PY4	1997-PY5	1998-PY6	1999-PY7
MPA Appropriation									
Pay/Allowances	266977172	264348600	261965928	239445264	227248872	227248872	227248872	227248872	227248872
ACF Cost	0.0000	0.0000	7921022	7921022	7921022	7921022	7921022	7921022	7921022
EB Cost	8553701	10636234	10515055	10515055	10515055	10515055	10515055	17321952	27060979
Total MPA	275530873	274984834	280402005	257881341	245684949	245684949	245684949	252491846	262230873
OMA Appropriation									
Rctr Support 871711	83194700	87252399	87940149	87861941	83512227	83200882	82945093	82740683	82155648
Commo 878795	19556645	17337288	16637220	15352269	14435542	14435542	14435542	14435542	14435542
Advertising 871712									
Enl. National Adv	20736630	21909704	30642308	30881167	30804204	30775790	30790836	30578713	29933171
Adv Sustainment	5729227	1000000	16321154	7176233	7440715	7435884	7438442	7402381	7292639
Total Advertising	26465857	22909704	46963462	38057400	38244919	38211674	38229278	37981094	37225810
HQ Mgt (AMHA)871798	9516000	8016000	8551000	8544000	8540000	8482000	8481000	8477000	8472000
ADP 871715	19206000	17135000	17135000	13916000	15191000	17135000	18135000	13635000	13635000
Civ Tng 878751	97000	170000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
A/V 879790	1717000	1484000	1284000	1484000	1484000	1484000	1484000	1484000	1484000
Total P87 (-Leases)	159753202	154304391	178510831	165215610	161407688	162949098	163709913	158753319	157408000
Leases 871996	36574560	38764467	37865585	38216690	38124950	37971294	36749978	36749978	36749978
2d Dst 728010	45000	46000	42000	38000	37000	37000	37000	37000	37000
Mil Tng 814771	3648000	4010000	4140000	4146000	4142000	4142000	4135000	4135000	4135000
QRIP 951215	27000	63000	68000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Other OMA Cost	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total Others	3720000	4119000	4250000	4184000	4179000	4179000	4172000	4172000	4172000
Total OMA	200047762	197187858	220626416	207616300	203711638	205099392	204631891	199675297	198329978
Total Cost	475578635	472172692	501028421	465497641	449396587	450784341	450316840	452167143	460560851

Alternative: 1
Running mode: Mode 1
Running time: Fri Dec 04 14:14:24 1992

	1991-BASE_YR	1992-CY1	1993-PY1	1994-PY2	1995-PY3	1996-PY4	1997-PY5	1998-PY6	1999-PY7
MPA Appropriation									
Pay/Allowances	266977172	264348600	271906882	256595780	252535504	260444204	270355970	270355970	281168772
ACF Cost	0.0000	0.0000	7921022	7921022	7921022	7921022	7921022	7921022	7921022
EB Cost	8553701	10636234	10515055	10515055	10515055	10515055	10515055	17321952	27060979
Total MPA	275530873	274984834	290342959	275031857	270971581	278880281	288792047	295598944	316150773
OMA Appropriation									
Rctr Support 871711	83194700	87252399	89934484	91745615	89180823	90689976	92299465	94009309	94248311
Commo 878795	19556645	17337288	17241662	16439971	15938699	16432869	16942181	17466634	18720642
Advertising 871712									
Enl. National Adv	20736630	21909704	32983411	35774013	37889170	41312450	44500390	47571035	53973451
Adv Sustainment	5729227	1000000	17491706	8154803	8645159	9227117	9769066	10291076	11379487
Total Advertising	26465857	22909704	50475117	43928816	46534329	50539567	54269456	57862111	65352938
HQ Mgt (AMHA)871798	9516000	8016000	8551000	8544000	8540000	8482000	8481000	8477000	8472000
ADP 871715	19206000	17135000	17135000	13916000	15191000	17135000	18135000	13635000	13635000
Civ Tng 878751	97000	170000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
A/V 879790	1717000	1484000	1284000	1484000	1484000	1484000	1484000	1484000	1484000
Total P87 (-Leases)	159753202	154304391	184621263	176058402	176868851	184763412	191611102	192934054	201912891
Leases 871996	36574560	38764467	39241268	40924328	42094860	43225070	43131375	44466527	47658978
2d Dst 728010	45000	46000	42000	38000	37000	37000	37000	37000	37000
Mil Tng 814771	3648000	4010000	4140000	4146000	4142000	4142000	4135000	4135000	4135000
QRIP 951215	27000	63000	68000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Other OMA Cost	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total Others	3720000	4119000	4250000	4184000	4179000	4179000	4172000	4172000	4172000
Total OMA	200047762	197187858	228112531	221166730	223142711	232167482	238914477	241572581	253743869
Total Cost	475578635	472172692	518455490	496198587	494114292	511047763	527706524	537171525	569894642

The SHARE software system will be described in detail in the User's Manual.

1. View Data Module

1) Historical Data

This module shows historical data at the command level. The data include all DEA inputs and outputs for the base year. These data are:

- Inputs

    Army on-production recruiters

    DoD recruiters

    Unemployment rate

    Local advertising

    TV GRP

    Radio GRP

    Print GRP

- Output

    GSMA net contracts

In a separate window, SHARE shows the elasticity for each input. These values are output from the DEA-Enhanced Goal Programming Model. They are constants in the FAARRS-SHARE model.

(2) Graphical Representation of Approximate Production Function

This module provides two two-dimensional graphical representations of the approximate production function. These displays are:

(i) Efficient GSMA net contracts as a function of the efficient number of Army on-production recruiters. In the graph, the horizontal axis shows the number of recruiters and the vertical axis corresponds to GSMA net contracts. The function curve intuitively shows the relation between contracts and recruiters;

(ii) GSMA net contracts as a function of national advertising media driver costs. The horizontal axis represents advertising driver costs and the vertical axis corresponds to GSMA net contracts.

Other data elements displayed reflect the base year's data.

2. Alternative Module

The alternative data displayed herein are analyst controlled parameters. These parameters are input data for the SHARE model. They directly affect the forecasting results. These parameters consists of:

- On-production recruiters.

- Manpower constraints.

    Includes HQDA, USAREC, BDE & below officers, enlisted and civilians.

- USAREC structure and unit costs.

    Includes numbers of brigades, battalions, companies, and stations and the unit costs for each category.

- Inflation indices.

    Includes OMA, TV, Radio and Print inflation rates. Also includes MPA officer, enlisted and civilian actual pay rates.

- ACF actuarial rates.

    Includes 2, 3, and 4 year ACF actuarial rates and proportions of takers.

- EB actuarial rates

- Recruiter environment.

    Includes DoD recruiters, prime market and unemployment rate.

- Recruiter, communication base year cost

- Advertising.

    Includes advertising cost proportion, advertising media mix rates, costs per point and advertising sustainment costs.

- Leased facility rate.

- Accession workload input.

    Includes GSMA, I-IIIA, and total NPS accessions and their corresponding proportions. SHARE provides a built-in calculator in this window. It allows the user to specify NPS accessions and adjust proportions to meet mission requirements.

- DEP posture.

    Includes percentage of GSA completed, percentage of total and DEP loss rates (GSMA and others).

- One time costs.

    Includes recruiting and advertising costs.

- Model constraints.

    This window displays two kinds of data. They are:

    (a) Feasibility bounds for the number of recruiters and advertising driver costs. Prior to running the model, the user may specify values for the number of recruiters and advertising cost which reflect reasonable or desirable limits on these factors in

attaining a specified number of contracts. When running an alternative to achieve a desired level of production, the forecasted number of recruiters or national advertising driver costs may fall outside the range of desirable or acceptable values. In which case SHARE gives a warning message in a special window, showing the user specified input bounds and the forecasted results for the years which are out of range. It also suggests that the user change corresponding input data or adjust the bounds and re-run the model. The originally forecasted results, however, may still be viewed via the Report menu.

(b) Constraints on number of recruiters and advertising cost. This allows the user either to fix the number of recruiters while forecasting advertising cost or to set an upper bound on advertising cost while forecasting the number of recruiters needed for the current parameter set. These data are used only in forecasting resources and costs.

In this module, SHARE provides six alternative modes of forecasting: Original Alternative, Alternative 1, ..., Alternative 5. For each alternative, SHARE provides two sets of parameters. SHARE also provides two ways -- view and modify -- to access these alternatives. The data in Original Alternative is provided by HQDA. They are reserved for reference and cannot be changed except when updating the base year.

When the modify function is selected, SHARE will query the user as to the direction in which the model is to be run: Forecasting Resources and Costs or Forecasting Production. SHARE will use the corresponding parameter set to make projections. In each forecasting direction a menu is displayed with a list of the relevant set of parameters. The user may choose one or more items from the list, enter a spreadsheet window, and then use the editor key to alter data. All data for eight forecasted years can be changed, but data for the base year cannot be changed and are constants for operation of the system.

The advantage of providing multi-alternatives is that the user can set different parameters for different recruiting scenarios, run the models separately, then compare and analyze the different forecasted results.

Another very useful function is "Reset," which reverts all values for the data elements of the current alternative to those of the original alternative.

The spreadsheet attached to SHARE is different from a commercial spreadsheet. It is designed for SHARE's special purposes. It shows 3 years and 10 rows of data in the window at one time. To change any data item, the user moves the cursor to that data field and presses the F5 key. A small editor window will pop-up for the user to make the changes in this window. When the changes are completed, the window will disappear from the spreadsheet.

The spreadsheet also allows the user to print data screens by pressing just one key. For convenient reference, the software automatically adds to the printout descriptive information about the current alternative. SHARE also provides a separate program called SETPRINT.EXE to ready the printer for the spreadsheet. Accordingly, this spreadsheet can print on either dot matrix printers or laser printers.

Another feature of the SHARE spreadsheet is that it passes data directly to a computer's Video RAM. This is the fastest way to display characters on the screen; it requires special techniques for implementation, but it is very efficient. Also, the SHARE spreadsheet uses functions from the BIOS library so that minimal waiting time is experienced when changing screens or writing data.

3. Run Model

SHARE provides two directions for forecasting: forecasting resources and costs (Y --> X) and forecasting production (X -> Y). Three running modes are provided in each direction. In the first direction, starting with base year data, the given desired accessions are converted into GSMA net contracts via DEP experience and policy. Then, SHARE forecasts by year the needed OPR, national media GRP and all associated costs. The three modes are as follows:

Mode 1 - Unconstrained forecasting of resources and associated costs;

Mode 2 - Constrained forecasting of resources and associated costs under a fixed number of recruiters;

Mode 3 - Constrained forecasting of resources and associated costs with an upper bound on total national advertising media costs.

In the reverse direction, with specified OPRs or national advertising media cost, the accessions can be forecast. The three modes are as follows:

Mode 4 - Forecasting production using OPRs and national media GRPs;

Mode 5 - Forecasting production using OPRs, national advertising media dollars, and media GRP costs per point;

Mode 6 - Forecasting production by OPRs, national advertising media proportion of cost, media mix rates, GRP costs per point, and enlistment pay.

Alternative recruiting scenarios can be run under different running modes to obtain a variety of results.

A window provides for checking on the feasibility of alternative scenarios, that is, on the compatibility of user specified bounds on inputs with prescribed levels of output. When running an alternative to achieve a desired level of production under Modes 1 - 3, the forecasted number of recruiters or national advertising driver costs may fall outside the range of desirable or acceptable values. In which case SHARE gives a warning message in a special window, showing the user specified input bounds and the forecasted results for the years which are out of range. It also suggests that the user change corresponding input data or adjust the bounds and re-run the model. The originally forecasted results, however, may still be viewed via the report capability.

Another function in this module is analysis of the Recruiters - Advertising Cost Trade-Off associated with a prescribed level of production in a specified year. The user can select any forecasted year (PY1-PY7) for such analysis. When the year is selected, the number of recruiters forecasted for that year will be displayed on the screen. The user can perturb this number by inputting a proportional change to be applied to it. Pressing any key will provide the trade-off results instantly. The displayed results include information on the new level of contracts that could be achieved without a compensatory change in advertising, the associated changes in several cost elements, and the change in advertising cost that would be required to achieve the original level of contracts.

4. Report Module

This module reports via spreadsheets and graphics the results of forecasting under the different modes available.

1) Results from Forecasting Resources and Costs (Modes 1 - 3).

There are two forms of reports for forecasting in this direction - Spreadsheet and Graphics. Spreadsheet results include the following:

- Cost by Program Element
  - Forecasted Program Element
    - Recruiters
    - Advertising
    - Communications
    - Enlistment Bonus
    - Army College Fund
  - Calculated Program Element
  - Workload Reports
- Total Cost (Constant $)
- Total Cost (Current $)

These results can be printed directly from the spreadsheet. For convenience, the printout also contains important descriptive information on the alternative being run.

Results shown in graphical form include the following:

- Program Elements
  - Recruiters
  - Advertising
  - Communications
  - Enlistment Bonus
  - Army College Fund
- Total Cost (Constant $)
- Total Cost (Current $)

In the graphical window display, different colors depict different data elements for easy comparison.

2) Results from Forecasting Production (Modes 4 - 6).

In this direction all results are given in spreadsheet form. These results include:

- Net and total contracts for categories GSMA, I-IIIA, and NPS

- Total Cost (Constant $)

- Total Cost (Current $)

5. Changing The Base Year

When one fiscal year is over and HQDA has available the new year's actual data, the base year data required for SHARE forecasting can be updated.

This module encompasses the entire process required to update the base year. In accessing this module, the user is presented with a list of menu functions to work with. These functions are:

1) Change Base Year

2) Update Inputs

3) Update Outputs

4) Update HOPS

5) Update Original Alternatives

6) View / Edit Factor

7) Run Update Module

8) Undo Update

The following sequence of three steps is recommended for updating the base year data.

Step 1. Select function 1 from the menu list above.

This item has three purposes: (1) changing the base year's mark (for example, from 1991 to 1992); backing up all original alternative data for the old base year (to provide the user an opportunity to return to the old base year); (3) creating an original alternative for the new base year (the first column of data) and adding data for a new 8th forecasted year (the last column of data).

Step 2. Select functions 2 - 6.

Functions 2 and 3 are for changing the *input and output data* of the FAARRS-SHARE formula, such as OPR, DOD Recruiters, Unemployment rate, Local Advertising, TV GRP, Radio GRP, Print GRP and GSMA net contracts.

Function 4 updates data used in the final summary cost. These data are not involved in other calculations.

Function 5 contains a list of alternatives. This is the only place for the user to change data in the original alternative.

Function 6 is to update the efficiency adjustment factor. The factor value should be between 1.02 and 1.10.

Step 3. Run Function 7.

This sequence of steps will change all data elements required for the FAARRS-SHARE formula. These data include Inputs, Outputs, HOPS data and all data in the original alternative.

The last function in this module is "Undo Update." It allows the user, for whatever reason, to return to the old base year data during the update procedure.

6. On-Line Help

On-line help is another important feature of the enhanced SHARE software. When the SHARE spreadsheet displays data in a window under either the View / Edit Data or Alternative menu, a help window is provided for each kind of data cell. Information about any data item is retrieved and displayed in a window by moving the cursor to the field that contains that data

item and pressing the F1 key. SHARE also provides a compact built-in editor to allow the user to edit the information displayed in the help window. This feature provides great convenience in operating and maintaining the FAARRS-SHARE system since any information considered important can be input to the help screen. For example, each data item can be labelled by its source, time and frequency of update, or any other characteristic.

7. Calculation of The Number of Contracts

Suppose the desired number of accessions in GSMA, I-IIIA, and NPS are given for each year. The number of net contracts for each category is to be calculated from them. The SHARE formulae forecasts the resources needed from the number of net contracts, GSMA net contracts in particular.

If we look from year to year at the actual accession levels and number of net contracts, there is an an inventory equation connecting them. In each year t, a number of new contracts arrive. By adding this to the number of 'entry DEP' contracts, we obtain the number of contracts which are ready for use this year. Part of this year t amount is used for the accession, the rest is 'exit DEP' exiting from the DEP pool of year t. This number of exit DEP contracts will be taken as the entry DEP for the year t+1. The DEP inventory equation of year t can be written as follows:

Net Contracts [t] = Accessions [t] + Exit DEP [t] - Entry DEP [t].

In each year the size of the entry DEP is approximated by some fraction f_c of the desired accession level for that year where the subscript c can be GSMA, I-IIIA, or NPS according to the type of contract under consideration. This fraction f_c is given.

Entry DEP [t] = f_c·Accession [t].

As mentioned above, entry DEP of this year is in fact exit DEP of the previous year.

Exit DEP [t] = Entry DEP [t+1].

Since exit DEP of each year is obtained from entry DEP of the following year, exit DEP of the 7th year will then need information from entry DEP of the 8th year. This leads the software to require the users to input accession information for 8 years in order to do 7 year forecasting.

Total number of contracts is also calculated here. We consider total contracts for each category as the number of contracts signed in that year before some loss in DEP, and net contracts is the number of people who signed contracts and actually joined the Army. Therefore we have the equation

Net contracts [t] = Total Contracts [t] x (1 - DEP loss [t])

where

DEP loss [t] is the fraction of total contracts which is lost.

Then the number of total contracts of year t is

Total contracts [t] = Net contract [t] / (1 - DEP loss [t]).

The number of net contracts and total contracts are calculated in the same way for all categories - NPS, I-IIIA, and GSMA.

Software Implementation

CONTRAC.C is the code used for calculating number of contracts. The code reads NPS, I-IIIA, and GSMA accessions and other related parameters, then computes the corresponding number of net contracts. The number of total contracts is also computed by CONTRAC.C. It takes the number of net contracts calculated from the previous step and adds some additional amount as compensation for the DEP lost to determine the number of total contracts.

Number of NPS entry DEP, I-IIIA entry DEP and GSMA entry DEP are read from the data file ENTRYDEP.@@@ into arrays called npsentry[], i3aentry[], and gsentry[] respectively. The three categories of accessions are also read from the file WORKLOAD.@@@ into arrays called npsacc[], i3aacc[], and gsac[]. The arrays prcgs[] and prcnps[] are prepared to hold the percentage of GSMA accessions and NPS accessions which will be used to calculate the entry DEP's of the corresponding categories. DEP loss rates are given as GSMA DEP loss and other loss. The two loss rates are held by array gsloss[] and otherloss[]. The data in prcgs[], prcnps[], gsloss[], and otherloss[] are read from data file EDEPPOST.@@@.

All variables are of length 8, for the base year plus 7 years forecast, except gsacc[], i3aacc[], npsacc[], prcgs[], prcnps[], gsloss[], and otherloss[] which are declared as array of length 9 instead. The additional memory locations are for the information of the 9th year. This additional year information is needed to compute the 9th year entry DEP which is used as the exit DEP of the 8th year.

Except for the based year (t=0) and first out-year (t=1), we calculate entry DEP of year t as follows:

gsentry[t] = prcgs[t] * gsacc[t], for GSMA entry DEP;

i3aentry[t] = prcgs[t] * i3aacc[t], for I-IIIA entry DEP; and

npsentry[t] = prcnps[t] * npsacc[t], for NPS entry DEP.

Notice that I-IIIA and GSMA entry DEP calculations use the same percentage of accessions held in prcgs[].

The first two years (t=0, and t=1) entry DEP are given. The data in gsentry[], i3aentry[], and npsentry[] of these two years are read from data file ENTRYDEP.@@@.

After the entry DEP of year t is obtained, we then calculate the exit DEP of the same year. Since exit DEP of year t is in fact the entry DEP of the year t+1, the calculations are then the same as above except for the year index. "exit" is declared as a temporary variable holding the value of the exit DEP of year t. The calculation of exit DEP for each category is as follows:

exit = prcgs[t+1] * gsacc[t+1], for GSMA exit DEP of year t;

exit = prcgs[t+1] * i3aacc[t+1], for I-IIIA exit DEP of year t;

exit = prcnps[t+1] * npsacc[t+1], for NPS exit DEP of year t.

Now we are ready to compute the number of net contracts. The calculations are as follows:

$$gsma[t] = -gsentry[t] + exit + gsacc[t], \text{ for GSMA net contracts;}$$

$$i3a[t] = -gsentry[t] + exit + gsacc[t], \text{ for I-IIIA net contracts;}$$

$$nps[t] = -npsentry[t] + exit + npsacc[t], \text{ for NPS net contracts.}$$

Since number of GSMA net contracts of the base year is known. We simply read gsma[0], for t=0, from the data file OUTPUT.DAT.

The number of total contracts are calculated from the number of net contracts as follows:

$$totalgs[t] = gsma[t]/(1-gsloss[t]), \text{ for GSMA total contracts;}$$

$$totali3a[t] = i3a[t]/(1-otherloss[t]), \text{ for I-IIIA total contracts;}$$

$$totalnps[t] = nps[t]/(1-otherloss[t]), \text{ for NPS total contracts.}$$

Notice that GSMA DEP loss rates are read separately from other DEP loss rates.

After the number of net contracts and total contracts for all three categories are obtained, the data are printed into the output file called CONTRAC.OUT.

8. Forecasting The Number of Recruiters and GRPs

The year to year forecasting and updating within the SHARE software is accomplished by taking the ratio of the production equations for two consecutive years. These equations relate output (GSMA net contracts) and inputs (recruiters, advertising and other factors) in efficient production. Additional relations and historical data enable us to use these and obtain forecasts of actual recruiters and adverting costs. The production equation for a particular year j is as follows.

(1) $Y_j = A_j \prod_{i=0}^{3} x_{ij}^{q_i} (\overline{DoD})_j^{q_{DoD}} (Un)_j^{q_{Un}} (Lmps)_j^{q_{Lmps}} (Pop)_j^{q_1+q_2+q_3}$, where

where Y_j = number of GSMA net contracts in year j,

A_j = scaling factor for year j,

x_{0j} = number of OPRs in year j,

x_{1j} = TV GRPs in year j,

x_{2j} = Radio GRPs in year j,

x_{3j} = Print GRPs in year j,

$\overline{DoD}_j$ = The complement of non-Army DoD recruiters in year j.

The complement is obtained by subtracting the number of non-Army DoD recruiters from 2 times the maximum number of non-Army DoD recruiters in the past.

Un_j = Unemployment rate in year j,

$Lmps_j$ = Local advertising expenditure in year j,

Pop_j = the 17-21 year old population in year j,

c_i = elasticity of input i, i=1, 2, 3

(i=0 for OPRs, i=1 for TV GRPs, i=2 for Radio GRPs, i=3 for Print GRPs),

c_{DoD} = elasticity of DoD recruiters,

c_{Un} = elasticity of unemployment rate,

c_{Lmps} = elasticity of local advertising cost.

The number of GSMA net contracts is considered to be the output of this production equation, while number of OPRs and national media GRPs are driver inputs, and number of DoD recruiters, rate of unemployment and local advertising expenditure are non-driver inputs.

The driver inputs are expressed in terms of total driver cost in the production equation. The total driver cost is given by

(2) $d_j = a_{0j}x_{0j} + a_{1j}x_{1j} + a_{2j}x_{2j} + a_{3j}x_{3j}$, where

a_{0j} = OPR salary in year j,

a_{1j} = TV GRP cost per point in year j,

a_{2j} = Radio GRP cost per point in year j,

a_{3j} = Print GRP cost per point in year j.

Let z_j be the proportion of OPR salaries in the total driver cost of year j. Then the number of OPRs can be expressed as

(3) $x_{0j} = \left(\dfrac{z_j d_j}{a_{0j}} \right)$,

and the values of other driver inputs can be derived as

(4) $x_{ij} = \left(\dfrac{g_{ij}(1 - z_j)d_j}{a_{ij}} \right)$,

where

g_{ij} = proportion of total national advertising media cost of year j to be spent on medium i.

Hence, the production function (1) can be rewritten as follows:

$$(5) \quad y_j = A_j \prod_{i=1}^{3} \left(\frac{g_{ij}(1-z_j)d_j}{a_{ij}} \right)^{c_i} \left(\frac{z_j d_j}{a_{0j}} \right)^{c_0} \left((\overline{DoD})^{c_{DoD}} (Un)^{c_{Un}} (Lmps)^{c_{Lmps}} \right)(Pop)^{c_1+c_2+c_3}.$$

Suppose we are considering two consecutive years, say j=1 and j=2. The SHARE formula takes the ratio of the equations of two consecutive years as follows:

$$\frac{y_2}{y_1} = \frac{A_2 \prod_{i=1}^{3} \left(\frac{g_{i2}(1-z_2)d_2}{a_{i2}} \right)^{c_i} \left(\frac{z_2 d_2}{a_{02}} \right)^{c_0} (\overline{DoD})_2^{c_{DoD}} (Un)_2^{c_{Un}} (Lmps)_2^{c_{Lmps}} (Pop)_2^{c_g}}{A_1 \prod_{i=1}^{3} \left(\frac{g_{i1}(1-z_1)d_1}{a_{i1}} \right)^{c_i} \left(\frac{z_1 d_1}{a_{01}} \right)^{c_0} (\overline{DoD})_1^{c_{DoD}} (Un)_1^{c_{Un}} (Lmps)_1^{c_{Lmps}} (Pop)_1^{c_g}}$$

(6).

where $c_g = c_1 + c_2 + c_3$. In other words,

$$\frac{y_2}{y_1} = \frac{A_2 \prod_{i=1}^{3} \left(\frac{g_{i2}}{a_{i2}} \right)^{c_i} (z_2 a_{01})^{c_0} (1-z_2)^{c_i} d_2^{c_0+c_i} (\overline{DoD})_2^{c_{DoD}} (Un)_2^{c_{Un}} (Lmps)_2^{c_{Lmps}} (Pop)_2^{c_g}}{A_1 \prod_{i=1}^{3} \left(\frac{g_{i1}}{a_{i1}} \right)^{c_i} (z_1 a_{02})^{c_0} (1-z_1)^{c_i} d_1^{c_0+c_i} (\overline{DoD})_1^{c_{DoD}} (Un)_1^{c_{Un}} (Lmps)_1^{c_{Lmps}} (Pop)_1^{c_g}}$$

(7).

The scaling factors A_j from year to year are generally stable and cancel out in the ratio. Based on this ratio, we can forecast driver inputs of year j=2 when information for year j=1 is known. The ratio can be rearranged, with A_j's cancelling, to forecast total driver cost of year j=2, i.e., d_2, as follows:

$$d_2 = d_1 \left(\frac{y_2 \prod_{i=1}^{3} \left(\frac{g_{i1}}{a_{i1}} \right)^{c_i} (z_1 a_{02})^{c_0} (1-z_1)^{c_i} (\overline{DoD})_1^{c_{DoD}} (Un)_1^{c_{Un}} (Lmps)_1^{c_{Lmps}} (Pop)_1^{c_g}}{y_1 \prod_{i=1}^{3} \left(\frac{g_{i2}}{a_{i2}} \right)^{c_i} (z_2 a_{01})^{c_0} (1-z_2)^{c_i} (\overline{DoD})_2^{c_{DoD}} (Un)_2^{c_{Un}} (Lmps)_2^{c_{Lmps}} (Pop)_2^{c_g}} \right)^{\frac{1}{c_0+c_i}}$$

(8).

In order to simplify the formula, we separate the ratio into a product of several terms.

Let $h_{1j} = \prod_{i=1}^{3} \left(\frac{g_{ij}}{a_{ij}} \right)^{c_i}$.

Let $h_{2j} = (\overline{DoD})_j^{c_{DoD}} (Un)_j^{c_{Un}} (Lmps)_j^{c_{Lmps}}$.

Let $h_{3j} = (Pop)_j^{c_s}$.

Then define $H_j = h_{1j} h_{2j} h_{3j}$.

SHARE formula (8) then can be written as

$$(9) \quad d_2 = d_1 \left(\frac{y_2}{y_1}\right)^{\frac{1}{c_0+c_s}} \left(\frac{H_1}{H_2}\right)^{\frac{1}{c_0+c_s}} \left(\frac{z_1 a_{02}}{z_2 a_{01}}\right)^{\frac{c_0}{c_0+c_s}} \left(\frac{1-z_1}{1-z_2}\right)^{\frac{c_s}{c_0+c_s}}.$$

After we solve for d_2, all driver inputs x_{02}, x_{12}, x_{22}, x_{32} can be obtained via equations (3) and (4).

Although the number of OPRs for year 2 as given by the formula is x_{02}, the actual number of OPRs needed varies from x_{02} due to the known deviation from efficient performance by individual battalions in the recruiting command. We adjust x_{02} to actuality by a factor estimated from historical performance. Thus, the number of OPRs = x_{02} . AAF, where AAF is an *actuality adjustment factor*. The AAF calibration is specified each year during the updating procedure.

During the transition from year 1 to the next year, the number of OPRs which is carried over is x_{02} because the SHARE transition formula relates to optimal performance. Thereby the AAF factor will not have a compounding effect on the forecasting.

Software Implementation

The code used for forecasting drivers (OPRs, GRPs) is called FCASTX. After the 8 years data are read FCASTX does the calculation from one year to the next. In each iteration, FCASTX performs 6 steps in the calculation : gets cost parameters a_j, g_j; computes(or reads) OPR proportion z_j; calculates factor H_j; solves for new year driver cost d_2; forecasts number of OPRs; and forecasts GRPs.

read 8 years data

The 8 year data which are read into variables of length 8 and variables which contain some constant parameters are as follows.

cd[] : elasticities for driver inputs.

    cd[0] = elasticity for OPRs.

    cd[1] = elasticity for radio.

    cd[2] = elasticity for TV.

    cd[3] = elasticity for print.

cn[] : elasticity for non-driver inputs.

    cn[0] = elasticity for DoD recruiters.

    cn[1] = elasticity for unemployment rate.

cn[2] = elasticity for local advertising.

Dod2max : 2 * maximum DoD recruiters in the past.

All of cd,cn,DodComple are read from CI.DAT.

AAF : Actuality adjustment factor for number of OPRs.

Read from AAF.DAT.

ybar[] : number of GSMA net contracts.

Read from CONTRAC.OUT.

dod[] : number of DoD recruiters.

pop[] : population (converted from unit of 1000).

un[] : unemployment rate.

All of dod,pop,un are read from ENVIRON.@@@

local[]: local advertising.

Read from ADSSUST.@@@.

zuser[]: user specified OPR proportion of driver cost.

Read from ADSPROP.@@@.

Note : what shows on the screen are (1-zuser) or

the proportion for national media cost.

<u>Computing and Forecasting</u>

For each iteration, FCASTX updates index "yr" for year 0,1,..,7 and performs the following steps.

STEP 1) Read parameters.

Set number of GSMA net contracts of last year to y1.

Set number of GSMA net contracts of this year [yr] to y2.

$y1 = ybar[yr-1]$, $y2 = ybar[yr]$.

Read cost parameters of this year into array ai[].

ai[0] = enlistment pay. Read from INFLAT.@@@.

ai[1] = radio cost per point.

ai[2] = Print cost per point.

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ai[3] = TV cost per point.

All ai[1,2,3] are read from ADSPOINT.@@@.

Set a02 to be this year OPR salary, a02 = ai[0].

Keep a01 from previous iteration.

Read media mixed rates of this year into gi[].

gi[1] = proportion of radio.

gi[2] = proportion of print.

gi[3] = proportion of TV.

STEP 2) Compute (or read) OPR proportion of driver cost z.

z1 is the OPR proportion of driver cost in previous year.

z2 is the OPR proportion of driver cost of this year.

z's are user specified parameters, except for the base year and the first out-year which are calculated as

$z = ai[0]*dr[0]/PD$, where

$PD = ai[0]*dr[0]+ai[1]*dr[1]+ ai[2]*dr[2]+ai[3]*dr[3]$.

PD is the driver cost before forecasting.

Later, total driver cost will be computed from formula and represented by variable d2.

dr[] are drivers (OPRs and GRPs) given for only the base year and first out-year.

STEP 3) Compute the H factor.

The H factor accounts for the cost parameters, media mix rates, and non-driver inputs in the forecasting formula. H is broken into h1, h2, and h3, where $H = h1*h2*h3$, for computational convenience. The H factor for the previous year is denoted H1 and is retained from the previous iteration. The H factor for this year is denoted H2.

$h1 = (gi[1]/ai[1])^{cd[1]}$

$*(gi[2]/ai[2])^{cd[2]}$

$*(gi[3]/ai[3])^{cd[3]}$.

$h2 = (Dod2max-dod[yr])^{cn[o]}$

$*(un[yr])^{cn[1]}$

$*(local[yr])^{cn[2]}$.

$$h3 = (pop[yr])^{(cd[1]+cd[2]+cd[3])}.$$

Step 4) Compute new year total driver cost.

$d2$ = new year (index yr) total driver cost.

It is calculated by using the previous year driver cost $d1$.

$d1$ is kept from the previous iteration, except for the base year in which $d1$ is calculated directly from

$$d1 = ai[0]*dr[0]+ai[1]*dr[1]+ ai[2]*dr[2]+ai[3]*dr[3].$$

where driver inputs $dr[]$'s of the base year are given.

$d2$ is broken into many terms for convenience.

$$d2 = d1*T1*T2*T3*T4$$

$$T1 = (y2/y1)^{1/sumcd}$$

$$T2 = (H1/H2)^{1/sumcd}$$

$$T3 = [(z1*a02)/(z2*a01)]^{cd[0]/sumcd}$$

$$T4 = [(1-z1)/(1-z2)]^{sumadv/sumcd}$$

where $sumcd = cd[0]+cd[1]+cd[2]+cd[3]$

$sumavd = cd[1]+cd[2]+cd[3].$

Step 5) Forecast the number of OPRs.

For the actual number of recruiters we have

$$rec[yr] = AAF*(z2*d2/a02).$$

The AAF factor accommodates the inefficiency of the actual situation in that year.

Step 6) Forecast GRPs

da is a variable representing national advertising cost. It is calculated by

$$da = (1-z2)d2.$$

GRP for each type of media is computed corresponding to its proportion $gi[]$.

Radio GRP $rd[yr] = gi[1]*da/ai[1]$.

Print GRP $tv[yr] = gi[2]*da/ai[2]$.

TV GRP $mg[yr] = gi[3]*da/ai[3]$.

After all drivers are forecast, $a02$, $z2$, $H2$, and $d2$ are stored for the next iteration.

The calculation is done for 7 iterations (7 years forecast). The forecast values of number of OPRs and GRPs are written in file FCASTX.OUT.

Numerical Example:

Calculation of OPRs and GRPs 1992 corresponding to FAX of 21 MAY 92 by LTC Dave Thomas, HQDA

Base Year 1991 OPRs and GRPs calculation

Let index yr = 0.

Step 0) Read parameters

Elasticities of driver inputs.

Elasticity of number of OPRs is	$cd[0] = 0.6$.
Elasticity of radio GRP is	$cd[1] = 0.0214$.
Elasticity of print GRP is	$cd[2] = 0.005$.
Elasticity of TV GRP is	$cd[3] = 0.173253$.

Elasticities of non-driver inputs.

Elasticity of DoD recruiters is	$cn[0] = 0.0231$.
Elasticity of unemploy rate is	$cn[1] = 0.1456$.
Elasticity of local advertising is	$cn[2] = 0.0075$.

Dod2max is 2 times of maximum DoD recruiters in the past.

Dod2max = 25970.

Actuality adjustment factor is	AAF = 1.0263.

Step 1) Read data.

Number of GSMA net contracts of year 1991 is y1 = 45177.

Cost per point.

OPRs salary in 1991 is	$ai[0] = 27827$.
Radio cost per point in 1991 is	$ai[1] = 839$.
Print cost per point in 1991 is	$ai[2] = 3720$.
TV cost per point in 1991 is	$ai[3] = 7970$.

Let $a01 = ai[0] = 27827$.

Media mix rates.

Proportion of radio media cost is $\quad$ gi[1] = 0.18.

Proportion of print media cost is $\quad$ gi[2] = 0.18.

Proportion of TV media cost is $\quad$ gi[3] = 0.64.

Driver inputs.

Number of actual OPRs in base year 1991 is rec $\quad$ [0] = 4810.

Radio GRP of 1991 is $\quad$ rd[0] = 3270.

Print GRP of 1991 is $\quad$ mg[0] = 839.

TV GRP of 1991 is $\quad$ v[0] = 1866.

Non-driver inputs.

Number of DoD recruiters in 1991 is dod[0] = 7849.

Unemployed rate in 1991 is $\quad$ un[0] = 6.7.

Local advertising cost in 1991 is $\quad$ local[0] = 1287000.

population in 1991 is $\quad$ pop[0] = 8944000.

Step 2) OPR proportion in total driver cost of 1991, z1.

z1 = ai[0]*rec[0] / PD, where

PD = ai[0]*rec[0]+ai[1]*rd[0]+ai[2]*mg[0]+ai[3]*tv[0].

PD = 27827*4810 + 839*3270 + 3720*839 + 7970*1866

$\quad$ = 154584500.

z1 = 27827*4810 / 154584500 = .865856.

Step 3) Compute H factor

H factor of year 1991 is called H1.

H1 = h1*h2*h3.

$h1 = (gi[1]/ai[1])^{cd[1]}$

$\quad *(gi[2]/ai[2])^{cd[2]}$

$\quad *(gi[3]/ai[3])^{cd[3]}.$

$h1 = (.18/839)^{.0214}*(.18/3720)^{.005}*(.64/7970)^{.173253}$

$\quad = .155024.$

$h2 = (Dod2max-dod[0])^{cn[0]} * (un[0])^{cn[1]} * (local[0])^{cn[2]}$.

$h2 = (25970-7849)^{.0231} * (6.7)^{.1456} * (1287000)^{.0075}$

$= 1.83849$.

$h3 = (pop[0])^{cd[1]+cd[2]+cd[3]}$.

$h3 = (8944000)^{(.0214+.005+.173253)}$

$= 24.42835$.

$H1 = .155024 * 1.83849 * 24.42835 = 6.96234$.

Step 4) Total driver cost of 1991, d1.

$d1 = ai[0]*rec[0]+ai[1]*rd[0]+ai[2]*mg[0]+ai[3]*tv[0]$.

$d1 = 27827*4810 + 839*3270 + 3720*839 + 7970*1866$

$= 154584500$.

<u>First out year 1992 OPRs and GRPs calculation</u>

Let index yr = 1.

Step 1) Read data.

Number of GSMA net contracts of year 1992 from actual accessions is y2 = 60603.

(This widely diverges from target GSMA net contracts forecast from '90 of 42270.)

Cost per point.

OPRs salary in 1992 is	ai[0] = 28560.
Radio cost per point in 1992 is	ai[1] = 839.
Print cost per point in 1992 is	ai[2] = 3720.
TV cost per point in 1992 is	ai[3] = 7970.
Let a02 = ai[0] = 28560.	

Media mix rates.

Proportion of radio media cost is	gi[1] = 0.18.
Proportion of print media cost is	gi[2] = 0.18.
Proportion of TV media cost is	gi[3] = 0.64.

Driver inputs.

Actual number of OPRs in base year 1992 is rec   [0] = 4632.

(Forecast from '90 is 4005)

Radio GRP of 1992 is $\quad\quad\quad\quad\quad\quad\quad\quad$ rd[0] = 3270.

Print GRP of 1992 is $\quad\quad\quad\quad\quad\quad\quad\quad$ mg[0] = 839.

TV GRP of 1992 is $\quad\quad\quad\quad\quad\quad\quad\quad$ tv[0] = 1866.

Non-driver inputs.

Number of DoD recruiters in 1992 is dod[0] = 7819.

Unemployed rate in 1992 is $\quad\quad$ un[0] = 6.6.

Local advertising cost in 1992 is local[0] = 1287000.

population in 1992 is $\quad\quad\quad\quad$ pop[0] = 8692000.

Step 2) OPR proportion in total driver cost of 1992, z2.

z2 = ai[0]*rec[0] / PD, where

PD = ai[0]*rec[0]+ai[1]*rd[0]+ai[2]*mg[0]+ai[3]*tv[0].

PD = 28560*4632 + 839*3270 + 3720*839 + 7970*1866

$\quad\quad$ = 153026550.

z2 = 28560*4632 / 153026550 = .864490.

Step 3) Compute H factor

H factor for year 1992 is called H2.

H2 = h1*h2*h3.

$h1 = (gi[1]/ai[1])^{cd[1]}$

$\quad\quad *(gi[2]/ai[2])^{cd[2]}$

$\quad\quad *(gi[3]/ai[3])^{cd[3]}.$

$h1 = (.18/839)^{.0214}*(.18/3720)^{.005}*(.64/7970)^{.173253}$

$\quad\quad$ = .155024.

$h2 = (Dod2max-dod[0])^{cn[0]} *(un[0])^{cn[1]} * (local[0])^{cn[2]}.$

$h2 = (25970-7819)^{.0231}*(6.6)^{.1456}*(1287000)^{.0075}$

$\quad\quad$ = 1.834536.

$h3 = (pop[0])^{cd[1]+cd[2]+cd[3]}.$

$h3 = (8692000)^{(.0214+.005+.173253)}$

$= 24.28936.$

$H2 = .155024 * 1.834536 * 24.28936 = 6.90785.$

Step 4) Total driver cost of 1992, d2.

$d2 = d1 * T1 * T2 * T3 * T4$, where

$T1 = (y2/y1)^{1/sumcd}.$

$T2 = (H1/H2)^{1/sumcd}.$

$T3 = [(z1*a02)/(z2*a01)]^{cd[0]/sumcd}.$

$T4 = [(1-z1)/(1-z2)]^{sumadv/sumcd}.$

$sumcd = cd[0]+cd[1]+cd[2]+cd[3] = .799653.$

$sumadv = cd[1]+cd[2]+cd[3] \quad = .199653.$

$T1 = (60603/45177)^{1/.799653} \qquad = 1.4439.$

$T2 = (6.96234/6.90785)^{1/.799653} = 1.00987.$

$T3 = [(.86586*28560)/(.86449*27827)]^{.6/.799653} = 1.0209.$

$T4 = [(1-.86586)/(1-.86449)]^{(.199653/.799653)}. = .99748$

$d2 = 154584500 * 1.4439 * 1.00987 * 1.0209 * .99748$

$= 229541909.70.$

Step 5) Forecasting needed number of OPRs in 1992 to attain actual net contracts of 60603.

Number of OPRs in 1992 is rec[1].

$rec[1] = AAF * (z2*d2/a02)$

$= 1.0263 * (.864 * 229541909.7 / 28560) = 7130.80.$

(The OPRs actually numbered 4632 for this year).

Step 6) Forecasting national GRPs.

Let adverting cost of 1992 be da.

$da = (1-z2)*d2$

$= (1-.86449)*229541909.7$

$= 31105227.5.$

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Radio GRP for 1992 is rd[1] = da*gi[1]/ai[1].

rd[1] = 31105227.5 * (.18) / 839

     = 6673.35.

Print GRP for 1992 id mg[1] = da*gi[2]/ai[2].

mg[1] = 31105227.5 * (.18) / 3720

     = 1505.09.

TV GRP for 1992 is tv[1] = da*gi[3]/ai[3].

tv[1] = 31105227.5 * (.64) / 7970

     = 2497.78

This example shows that it was a most unusual year for recruiting. As was explained months ago, in such a situation you **must** use an **adjusted** z-base value for each year when updating base, especially when the actual year may involve unusual recruiting experiences (eg., Desert Storm reactions) which are different from reasonable expectations based on past experience.

9. Forecasting The Number of Contracts

When resources are given, use the SHARE formula ratio to forecast the number of GSMA net contracts as follows.

$$Y_2 = Y_1 \frac{H_2}{H_1} \frac{\prod_{i=0}^{3} (x_{i2})^{c_i}}{\prod_{i=0}^{3} (x_{i1})^{c_i}}$$

where $i = 0,...,3$ are subscripts for the 4 driver inputs; H_1, H_2 contain the non-driver input values of the two consecutive years; and Y_1, Y_2 are the GSMA net contracts of the two consecutive years. H_1 and H_2 are calculated as when forecasting in the direction from net contracts to resources. For Y_1 we have the actual number of GSMA net contracts in the base year.

Once the number of GSMA net contracts has been calculated, the number of I-IIIA net contracts and NPS net contracts are derived through specified proportions. The software allows users to specify some fractions $f_{I\text{-}IIIA}$ as ratios of the number of I-IIIA net contracts to NPS net contracts, and fractions f_{GSMA} as ratios of the number of GSMA net contracts to NPS net contracts.

GSMA net contracts [t] = f_{GSMA}[t] NPS net contracts[t].

I-IIIA net contracts [t] = $f_{I\text{-}IIIA}$ [t] NPS net contracts[t].

Hence, given the number of GSMA net contracts we can derive the number of I-IIIA net contracts and NPS net contracts by rearranging the above equations.

$$\text{I-IIIA net contracts } [\, t\,] = \frac{f_{\text{I-IIIA}} [\, t\,] \text{ GSMA net contracts } [\, t\,]}{f_{\text{GSMA}} [\, t\,]}.$$

$$\text{NPS net contracts } [\, t\,] = \frac{\text{GSMA net contracts } [\, t\,]}{f_{\text{GSMA}} [\, t\,]}.$$

The number of total contracts can be derived from the number of net contracts as described above.

10. Modes of Forecasting

Forecasting within the SHARE software can be done in 6 modes. Modes 1 to 3 are for forecasting resources (OPRs, national advertising) based on a given number of required GSMA net contracts. Modes 4 to 6 are for forecasting the number of GSMA net contracts based on alternative recruiting environments which are specified by the user.

Mode 1, in which the values of the various factors are unconstrained, is the most fundamental forecasting method of SHARE. As described in the previous section, this mode forecasts the values of the drivers (OPRs and national GRPs) which corresponding to a given number of GSMA net contracts.

The calculations of modes 2 and 3 are essentially the same as those for mode 1, but additional restrictions are added. Mode 2 forecasts resources when the number of OPRs is fixed in advance. Mode 3 forecasts resources with an upper bound on national advertising cost.

Given the forecasted advertising cost d_A' and number of OPRs x_0', if the number of OPRs is now fixed at x_0'', the corresponding advertising cost d_A'' can be computed as follows:

$$d_A'' = d_A' \left(\frac{x_0'}{x_0''} \right)^{\frac{c_0}{c_g}}$$

where, c_0 is the elasticity of OPRs, and c_g is the sum of elasticities for national media GRPs.

Similarly, if the advertising cost is bounded at d_A'', the corresponding number of OPRs can be calculated as follows:

$$x_0'' = x_0' \left(\frac{d_A'}{d_A''} \right)^{\frac{c_g}{c_0}}$$

Forecasting the number of GSMA net contracts can be done either directly or indirectly. Mode 4 is the direct way to forecast, in which the user simply provides the number of OPRs and GRPs. The number of actual OPRs is first adjusted by dividing by the AAF to correspond to efficient production levels. Then the number of GSMA net contracts is obtained by solving the production equation specified in section 8.

In an indirect manner, driver inputs can also be obtained from user-specified total driver cost, OPR salary, advertising costs per point, media mix proportions and the OPR proportion of total driver cost. The driver inputs are calculated as follows:

$$x_{0j} = \frac{z_j \, d_j}{a_{0j}}$$

$$x_{ij} = \frac{g_{ij}(1-z_j)d_j}{a_{ij}}$$

where $i = 1, 2, 3$ denotes Radio, Print and TV GRPs, and $j = 1, 2$ for the two consecutive years.

Mode 5 computes GRPs from the specified advertising cost, and mode 6 calculates GRPs from the fixed media mix rates and OPR proportion of total driver cost..

The computations of each mode will overwrite a number of data files as follows. The results from mode 4 will overwrite advertising proportion, media mix rates, and advertising cost. The calculations of mode 5 will overwrite advertising proportion, media mix rates, and GRPs, and the output from mode 6 will overwrite advertising cost and GRPs. If the user wishes to forecast GSMA net contracts under some environment which is not allowed directly by any of the 3 modes specified above, then this can be achieved by constructing a sequence of forecasts making use of the overwriting feature described above.

11. Calculation of Enlistment Bonus and Army College Fund

The numbers of Enlistment Bonus takers (EB) and Army College Fund takers (ACF) in several categories are approximated by user-specified percentages of I-IIIA accessions. The associated costs are calculated by multiplying the number of takers in each category by the appropriate actual dollar rate for that category, also specified by the user.

EB takers are classified into two categories : new EB takers and Residual EB takers. The percentage in each category is user-specified. The calculations are as follows:

EB takers [t]   =   I-IIIA accessions x % EB / 100.

New EB [t]   =   EB takers [t]   x % New EB [t] / 100.

Residual EB [t] =   EB takers [t]   x % Residual EB [t] / 100.

Cost for New EB [t]   =   New EB [t] x Actual rate of EB cost [t].

Cost for Residual EB [t] =   Residual EB [t -1] x Actual rate of EB cost [t -1].

Cost for Incremental [t] =   EB takers [t] x Incremental rate [t].

Total EB cost for year t is the summation of new, residual, and incremental costs for year t.

ACF takers are classified into 3 categories : 2 year takers, 3 year takers , and 4 year takers. The percentage in each category is also specified by the user. The calculations are as follows:

2 year ACF takers [t] = I-IIIA accession x % 2 year ACF takers [t] / 100.

3 year ACF takers [t] = I-IIIA accession x % 3 year ACF takers [t] / 100.

4 year ACF takers [t] = I-IIIA accession x % 4 year ACF takers [t] / 100.

Cost for 2 year ACF [t] = 2 year ACF takers [t] x 2 year ACF actual rate [t].

Cost for 3 year ACF [t] = 3 year ACF takers [t] x 3 year ACF actual rate [t].

Cost for 4 year ACF [t] = 4 year ACF takers [t] x 4 year ACF actual rate [t].

Total ACF cost for year t is the summation of costs for the 3 categories in year t.

12. Calculation of Recruiting Support Cost (PE 871711)

Recruiting support cost is composed of personal pay and 16 other PE components. In each year when there is some change in command structure, for example when the number of battalions is reduced, there will be a corresponding reduction in recruiting support cost.

The number of military personnel (officer and enlisted) and civilians are approximated by multiplying the number of OPRs by different factors. The salary paid to each category is specified by the user in actual dollars.

$$\text{Officer pay} [t] = ((f_o [t] \times \text{OPR} [t]) + \text{Hq officer} [t]) \times \text{Officer pay} [t_1]$$

$$\text{Enlisted pay} [t] = ((f_e [t] \times \text{OPR} [t]) + \text{Hq enlisted} [t]) \times \text{Enlisted pay} [t_1]$$

$$\text{Civilian pay} [t] = (f_c [t] \times \text{OPR} [t]) \times \text{Civilian pay} [t_1]$$

where f_o, f_e, and f_c are factors applied to OPR to obtain the numbers of officers, enlisted, and civilian personnel, respectively, Hq denotes headquarters level, and t_1 is the first out-year in the time horizon. When cost is calculated in constant dollars, the officer, enlisted and civilian pay rates are those relevant to the first outyear; $t_1 = t$ when current dollars are considered.

Only personnel at the brigade and below level are considered to be driven by OPR. The number of personnel at the headquarters level are fixed and specified by the user. Notice that headquarter civilians are not included in recruiting support cost.

The 16 PE components included in recruiting support are Vehicles, BACH, COI, DEP, EDTOUR, NRSTOU, REA, APMLT, MILAWD, EQUIP, MSNTVL, RCTRTN, CIVTNG, QOL, TAIR, OTHER. These elements are driven by either the number of OPRs or the number of total NPS contracts. The elements driven by number of OPRs are Vehicles, BACH, REA, MILAW, EQUIP, RCTRTN, QOL. The remainder, with the exception of CIVTNG, are driven by the number of total NPS contracts. The cost of CIVTNG is calculated in the same way as the number of civilians at brigade and below level.

The total variable cost and fixed cost of each of these 16 components for a base year are given. Unit variable cost for a component is calculated by dividing its total base year variable cost by the number of OPRs or the number of total NPS contracts according to the driver for that PE component. For example,

$$\text{Unit variable cost of EQUIP} = \text{Variable Cost of EQUIP} [t_0] / \text{OPR} [t_0].$$

where t_0 denotes base year.

Cost for a PE component in year t is computed as unit variable cost multiplied by the value of its driver in year t plus fixed cost, adjusted by the OMA inflation index. For example,

Cost of EQUIP $[t]$ = (Unit variable cost of EQUIP $\times$ OPR $[t]$ + Fixed cost of EQUIP) $\times$ OMA inflation index $[t_1]$.

Again, t_1 is fixed as the first out-year when constant dollars are considered, and $t_1 = t$ when current dollars are calculated.

As the recruiting command structure changes, most likely through downsizing, the change in the number of brigades, battalions, stations, and companies has an affect on recruiting support cost. The unit cost savings of reduction are specified by the user. The amount of reduction cost savings for each year is calculated by multiplying the unit cost savings by the number of brigades, battalions, stations, and companies reduced from the base year, adjusted by the OMA inflation index.

Brigade reduction cost $[t]$ = (# of Brigades $[t_0]$ - # of Brigades $[t]$) $\times$

Brigade structure unit cost $\times$ OMA inflation index $[t_1]$.

Battalion reduction cost $[t]$ = (# of Battalions $[t_0]$ - # of Battalions $[t]$) $\times$

Battalion structure unit cost $\times$ OMA inflation index $[t_1]$.

Company reduction cost $[t]$ = (# of Companies $[t_0]$ - # of Companies $[t]$) $\times$

Company structure unit cost $\times$ OMA inflation index $[t_1]$.

Station reduction cost $[t]$ = (# of Stations $[t_0]$ - # of Stations $[t]$) $\times$

Station structure unit cost $\times$ OMA inflation index $[t_1]$.

where t_0 again denotes the base year and t_1 the first out-year in a constant dollars calculation, and $t_1 = t$ in a current dollars calculation.

Total recruiting support cost is the sum of personal pay and the cost due to the 16 PE components minus the cost savings from any change in structure.

13. Calculation of Communication Cost (PE 878795)

Communication cost is considered to be driven by the number of personnel excluding those at Headquarters. When there is a change in structure, communication cost is affected in a similar manner to that of recruiting support cost.

The number of personnel (officer, enlisted, and civilian) are obtained as shown in the previous section except that headquarters personnel are not included.

Number of officers $[t]$ = $f_0[t] \times$ OPR $[t]$

Number of enlisted $[t]$ = $f_e[t] \times$ OPR $[t]$

Number of civilians $[\, t\,]$ = $f_c\, [\, t\,]$ x OPR $[\, t\,]$

where f_o, f_e, and f_c are defined as before.

Base year communication variable cost and fixed cost are given. Unit variable cost is obtained by dividing base year variable cost by the number of personnel in the base year. Then, communication cost of year t (before any cost savings from downsizing are subtracted) is given by

Commo cost $[\, t\,]$ = Unit variable cost x # of personnel $[\, t\,]$ x OMA inflation index $[\, t_1\,]$

where # of personnel is the sum of the number of officer, enlisted, and civilian personnel as calculated above. Again, t_0 denotes the base year and t_1 the first out-year in a constant dollars calculation, and $t_1 = t$ in a current dollars calculation.

Cost savings from a structural change are calculated in the same manner as for recruiting support cost except that structure unit cost savings for brigade, battalion, company, and station are those relevant to the PE 878795 structure cost element.

14. Calculation of Advertising Cost (PE 871712)

Advertising cost includes national media advertising cost and advertising sustainment cost. Although national media advertising cost varies by forecasted GRP's, advertising sustainment cost is fixed and specified by the user.

National media advertising cost is the sum of radio GRP cost, print GRP cost, and TV GRP cost, each of which is adjusted by its respective inflation index.

Rd GRP cost $[\, t\,]$ = Rd GRP $[\, t\,]$ x Rd cost per point $[\, t\,]$ x Rd-Pr inflation $[\, t_1\,]$

Pr GRP cost $[\, t\,]$ = Pr GRP $[\, t\,]$ x Pr cost per point $[\, t\,]$ x Rd-Pr inflation $[\, t_1\,]$

TV GRP cost $[\, t\,]$ = TV GRP $[\, t\,]$ x TV cost per point $[\, t\,]$ x TV inflation $[\, t_1\,]$

where Rd, Pr and TV denote radio, print and television, respectively.

In general, inflation indices equal 1 for the base year and compound at a certain rate from the first out-year onward. However, the national advertising inflation indices start compounding from the second out-year. This is because, in the first out-year, inflation is already accounted for in the media costs per point for that year.

The user can change the way that costs per point are handled, with unit costs given in base year dollars or first out-year dollars, since both the inflation indices and the costs per point can be specified by the user. Currently, costs per point are given in first out-year dollars, and the inflation indices of that year are set equal to 1.

15. Calculation of Leased Facilities Cost (PE 871996)

The overall DoD lease cost and unit structure cost are fixed; they can be changed only when the software is updated for the next base year. However, the percentage of yearly lease cost which is attributed to the Army can be specified by the user. The lease costs also are reduced when there is a downsize in structure. These costs also are adjusted by the OMA inflation index.

US Army lease costs $[t] = ($ Overall lease costs $\times$ % due to Army $[t]$

$$- \text{Reduction } [t]) \times \text{OMA inflation index } [t_1]$$

where

Reduction $[t] = ($ # battalion $[t_0]$ - # battalion $[t]) \times$ Battalion lease cost $[t]$

$$+ (\text{# company } [t_0] - \text{# company } [t]) \times \text{Company lease cost } [t]$$

$$+ (\text{# station } [t_0] - \text{# station } [t]) \times \text{Station lease cost } [t].$$

and t_0 denotes the base year, t_1 is the first outyear for a constant dollars calculation , and $t_1 = t$ for a current dollars calculation.

16. Calculation For 'What If' Analysis

'What If' analysis involves a perturbation of the forecasted results in some particular year. We want to quantify the effect on several cost elements when the number of OPRs is changed and the tradeoff involved when GRPs are also changed correspondingly to achieve the original forecasted level of output.

Let p_w denote the proportional change in the number of OPRs which is specified by the user. Then we have the relationship

$$p_w = \frac{\overline{x}_{02}}{\overline{x}_{01}}$$

where $\overline{x}_{01}$ is the original number of OPRs, and $\overline{x}_{02}$ is the perturbed number of OPRs.

The new number of GSMA net contracts can be calculated through the SHARE ratio formula. The ratio simplifies to

$$\frac{Y_2}{Y_1} = \frac{K_2}{K_1} \left(\frac{x_{01}}{x_{02}}\right)^{c_0}.$$

K_1 and K_2 cancel each other out. The ratio of x_{01} and x_{02} can be replaced by the user specified proportion p_w, where the AAF factors embedded in $\overline{x}_{01}$ and $\overline{x}_{02}$ also cancel. Hence the equation to calculate the new number of GSMA net contracts is given by

$$\text{New # of GSMA contracts} = Y_2 = Y_1 p_w^{c_0}.$$

The number of total GSMA contracts is calculated from the number of net contracts as before.

The cost element changes involve only those related to the change in number of OPRs and total GSMA contracts such as MPA, PE 87 cost elements, and communication cost.

The MPA cost change is calculated as before except that headquarters personnel are not involved since they are considered unchanged when changing the number of OPRs.

PE 87 cost elements are calculated separately for recruiter related components and total contracts related components. Although the cost change involves both parts when the number of OPRs is changed, only the first part will be considered in the tradeoff when advertising dollars are added (or subtracted) to restore the original number of contracts.

Communication cost change is also calculated as before. Total cost change is then the sum of the cost changes in MPA, PE 87, and communication.

To calculate the change in advertising dollars needed in order to maintain the original number of net contracts we also utilize the SHARE ratio formula,

$$\frac{Y_2}{Y_1} = \frac{\overline{K}_2}{\overline{K}_1} \left(\frac{x_{01}}{x_{02}}\right)^{c_0} \left(\frac{d_{A1}}{d_{A2}}\right)^{c_g} ,$$

where d_{A1} and d_{A2} are advertising cost for GRPs before and after the change.

$\overline{K}_1$ and $\overline{K}_2$ are still considered fixed and cancel each other. When Y_1 equals Y_2 the new advertising expense is given by

$$\text{New advertising expense} = d_{A2} = d_{A1} \left(\frac{x_{01}}{x_{02}}\right)^{\frac{c_0}{c_g}} .$$

$$\% \text{ change in advertising expense} = \frac{d_{A2} - d_{A1}}{d_{A1}} \times 100.$$

The changes required in radio GRPs, print GRPs and TV GRPs are calculated from the change in total advertising cost by using media proportions and costs per point as before.

The tradeoff between changing the number of OPRs and changing the advertising expense is then calculated as follows:

$$\% \text{ Trade off} = \frac{\text{Recruiting support cost change - Advertising cost change}}{\text{Original recruiting support cost + Original advertising cost}} \times 100$$