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THE STRAP ENLISTED PREDICTOR: (STEP), (U)

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JUL 81 J I BORACK, K W GRAY

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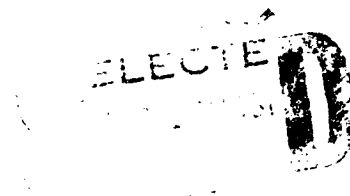
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THE STRAP ENLISTED PREDICTOR (STEP)

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manpower requirements determination, personnel policy evaluation, accession requirements determination, manpower supply forecasting, and personnel flow/loss estimation. This report describes the STRAP Enlisted Predictor (STEP) module, which provides STRAP with estimates of personnel flows and losses.

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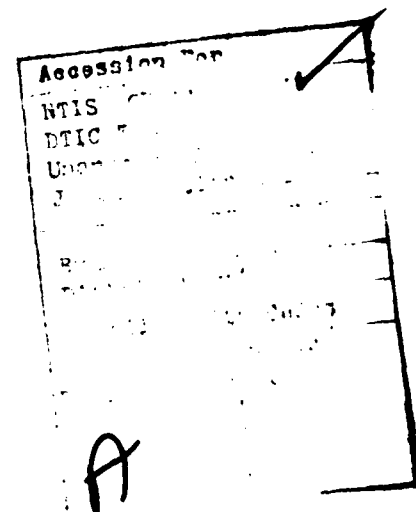
FOREWORD

The work described in this report supports the development of Structured Accession Planning, an exploratory development objective under Task Area ZF63-521-001-010 (Manpower Management Decision Technology), Work Unit 3.16 (Accession Planning Models). The overall objective of the task area is to develop techniques to improve the Navy's managerial decision-making capabilities. The objective of the work unit is to develop a computerized system and supporting methodology to analyze trade-offs between enlisted manpower requirements, personnel policies, and available enlisted manpower supply.

This report describes a system that is used to forecast the movement of enlisted personnel through the Navy personnel force structure. This system is a module of the Structured Accession Planning System (STRAP). A prototype version of the STRAP system was installed in OP-01 (under the sponsorship of OP-12) in November 1979. Experience gained in the use of the prototype was used in the subsequent redesign of STRAP.

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SUMMARY

Problem

Two major studies, the Defense Manpower Commission Report and the Salzer Report, both concluded that Total Force Management is not a reality, due in part to fragmentation of responsibility for various key aspects of manpower management. Problems caused by this fragmentation are further compounded by the lack of management systems and techniques for integrated manpower management.

A new computerized management system, the Structured Accession Planning (STRAP) system, is being developed to help alleviate this deficiency. Specifically, STRAP is a computerized system and supporting methodology that facilitates analysis of trade-offs between enlisted force manpower requirements, personnel policies, available enlisted manpower supply, and cost implications. The STRAP system consists of a series of computerized modules that focus on manpower requirements determination, personnel policy evaluation, accession requirements determination, manpower supply forecasting, and personnel flow/loss estimation.

Objective

The objective of this effort was to develop procedures for personnel flow/loss estimation and to integrate these procedures into the STRAP system. The resulting subsystem is called the STRAP Enlisted Predictor (STEP).

Methodology

STEP develops forecasts of Navy enlisted personnel flows by estimating the percentage of individuals with given attributes at the beginning of a fiscal year (or at the time they entered the Navy) who "flow" in a specific way during the year. For individuals who have served less than 12 years, forecasts are based upon length of service (LOS), pay grade, time remaining on contract, sex, and "quality" as defined by education and mental group. Thus, the demographic, longevity, pay grade, and contract obligation dimensions of the enlisted force are accounted for in the numeric forecasts obtained from STEP.

For individuals who have served at least 12 years, forecasts are based upon LOS and pay grade. Thus, the longevity and pay grade dimensions of this "senior" enlisted force is accounted for in the forecasts.

STEP is comprised of two major components: (1) the Enlisted Loss/Flow forecast data base generator (ELF), and (2) the Enlisted Cohort Model/ELF Linkage (EEL). ELF generates matrices of data needed to forecast the personnel flows required by the Enlisted Cohort Model (ECO). These personnel flows include attrition, reenlistment bonus and extensions, advancement/demotion through pay grades E-1--E-3, loss due to expiration of active obligated service (EAOS), change in time remaining on contract, and prior service gains. EEL supplies forecasts of specified personnel flows to ECO. This is accomplished through a sequence of subroutines that utilizes inventories generated in ECO and the data base generated by ELF.

Results

Although STEP has been successfully integrated into the STRAP system, there are several potential improvements and extensions of the STEP forecasting methodology. Among them are the inclusion of additional variables and the use of statistical forecasting

techniques, such as time series analysis, which can be employed as the data base for the Enlisted Survival Tracking File expands in both time time period covered and the data elements included.

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INTRODUCTION

Problem and Background

Total Force Management is a concept under which all personnel resources available to a particular DoD service--active duty and reserve military, civilian, and contractor--are managed as a single resource. Under this concept, life cycle costs, personnel policies, and job requirements are jointly considered in an effort to arrive at an optimal force mix and deployment. Thus, human resources are managed with an eye to possible trade-offs among classes of personnel or manpower.

Two major studies, the Defense Manpower Commission Report and the Salzer Report,¹ both concluded that Total Force Management is not a reality, due in part to fragmentation of responsibility for key aspects of manpower management. This fragmentation in organization is subsequently reflected in management processes and methodologies, especially those involved in evaluating the relationships between alternative manpower requirements, personnel policies, and the available pool of qualified civilian and military manpower. Problems caused by this fragmentation are further compounded by the lack of management systems and techniques for integrated manpower management.

A new computerized management system, the Structured Accession Planning (STRAP) system, is being developed to help alleviate this deficiency. STRAP is a computerized system and supporting methodology that facilitates analysis of trade-offs between enlisted force manpower requirements, personnel policies, available enlisted manpower supply, and cost implications. The STRAP system consists of computerized modules that focus on the major determinants of manpower and personnel policy and also provide a platform for their integration. These modules include manpower requirements determination, personnel policy evaluation, accession requirements determination, manpower supply forecasting, and personnel flow/loss estimation.

Objective

The objective of this effort was to develop procedures for personnel flow/loss estimation and to integrate these procedures into the STRAP system. The resulting subsystem is called the STRAP Enlisted Predictor (STEP).

METHODOLOGY

Overview

STEP develops forecasts of Navy enlisted personnel flows by estimating the percentage of individuals with given attributes at the beginning of a fiscal year (or at the time they entered the Navy) who "flow" in a specific way during the year. For individuals who have served less than 12 years, forecasts are based upon length of service (LOS), pay grade, time remaining on contract, sex, and "quality" as defined by education and mental group. Thus, the demographic, longevity, pay grade and contract obligation dimensions of

¹Defense Manpower Commission. Defense Manpower: The Keystone of National Security. Washington, DC: U. S. Government Printing Office, April 1976.

and Salzer, R. S., Vice Admiral, USN (Retired). Navy Manpower and Personnel Management Study, 30 November 1977.

the enlisted force is accounted for in the numeric forecasts obtained from STEP. For individuals who have served at least 12 years, forecasts are based upon LOS and pay grade. Thus, the longevity and pay grade dimensions of this "senior" enlisted force is accounted for in the forecasts.

STEP is comprised of two distinct components: (1) the Enlisted Loss/Flow forecast data base generator (ELF), and (2) the Enlisted Cohort Model/ELF linkage (EEL). ELF generates arrays of data needed to forecast the personnel flows required by the Enlisted Cohort Model (ECO). These personnel flows are attrition, reenlistment and bonus extensions, advancement/demotion through pay grades E-1--E-3, loss due to expiration of active obligated service (EAOS), change in time remaining on contract, and prior service gains. EEL supplies forecasts of specified personnel flows to ECO. This is accomplished through a sequence of subroutines that utilize inventories generated in ECO and the data base generated by ELF.

A flow chart of STEP appears in Figure 1. Details of all components and data sets appearing in this flow chart are discussed in subsequent sections.

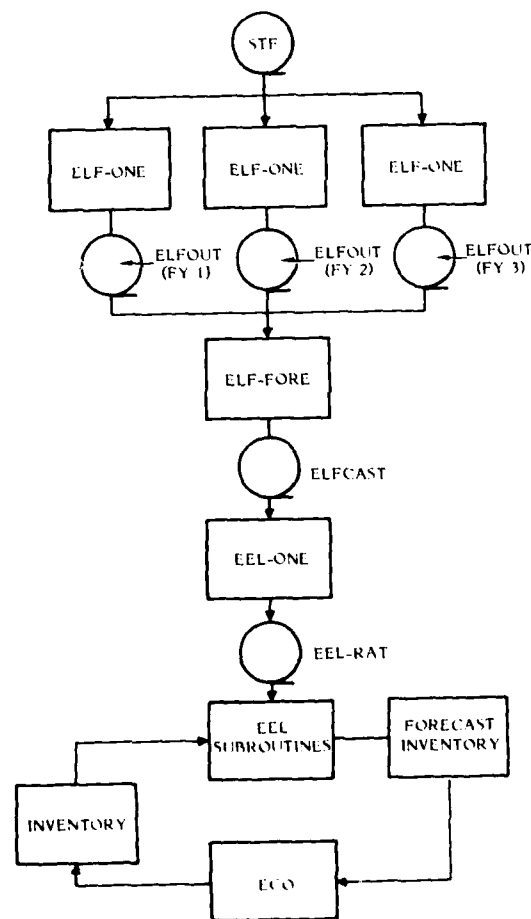


Figure 1. STEP components.

ELF Methodology

Let $I_{y,d,\ell,t,p}$ represent the inventory of individuals on active duty as of the beginning of fiscal year y , in demographic group (dem) d ($1 \leq d \leq 7$), active duty service date (ADSD) ℓ ($0 \leq \ell \leq 12$), years remaining to end of active obligated service (i.e., time remaining on contract (TRC)) t ($1 \leq t \leq 8$), and pay grade (PG) p ($1 \leq p \leq 10$). Let $I_{y,\ell,p}$ represent the inventory of individuals on active duty as of the beginning of fiscal year y with LOS ℓ ($13 \leq \ell \leq 31$) and PG p ($1 \leq p \leq 10$).

The definition of the subscript values is as follows.

1. $y = 78, 79$, etc. represents the beginning of fiscal year 1978, 1979, etc.
2. $d = 1$ represents males on active duty in the regular Navy (USN) in mental group I, II, or IIIU, who are high school diploma graduates (HSDG); $d = 2$ represents those in mental group I, II, or IIIU who are not high school diploma graduates (NHSDG); $d = 3$ represents those in mental group IIII, IV, or V who are HSDG, $d = 4$ represents those in mental group IIII, IV, or V who are NHSDG; $d = 5$ represents regular Navy females; $d = 6$ represents persons on active duty while serving in the naval reserve; and $d = 7$ represents the total $d = 1$ through 6.
3. $\ell = 0$ represents no active service at beginning of fiscal year; $\ell = 1$ represents more than 0 but less than 1 year of active service at beginning of fiscal year; $\ell = 2, \dots, 30$ represents at least $\ell-1$ but less than ℓ years of active service at beginning of fiscal year; $\ell = 31$ represents 30 or more years of service at beginning of fiscal year; and $\ell = 32$ represents the total of $\ell = 1$ through 31; that is, the total of all active duty individuals appearing on beginning fiscal year inventory.
4. $t = 1$ represents TRC less than 1 year; $t = 2, \dots, 6$ represents TRC at least $t-1$ years but less than t years; $t = 7$ represents TRC 6 years or more; and $t = 8$ represents the total of $t = 1$ through 7.
5. $p = 1, \dots, 9$ represents pay grades E-1, $\dots$, E-9; $p = 10$ represents the total of $p = 1$ through 9.

Let $G_{y,d,\ell,t,p}$ represent the inventory of gains (i.e., individuals who were not on active duty in a given branch and class as of the beginning of the fiscal year but who served on active duty in that branch and class at some time during the fiscal year), TRC = t and PG = p ; during fiscal year y , with DEM = d , LOS = ℓ ($0 \leq \ell \leq 12$); and let $G_{y,\ell,p}$ represent the inventory of gains during fiscal year y with LOS = ℓ ($13 \leq \ell \leq 31$) and PG = p .

The definition of all subscripts is as for $I_{y,d,\ell,t,p}$ and $I_{y,\ell,p}$, except for the following:

1. $\ell = 0$ indicates that the ADSD at time of gain² is within the fiscal year (referred to as non-prior-service gains); $\ell = 1$ indicates that the ADSD at time of gain is

²Specifically, ADSD as recorded on the enlisted master record (EMR) file as of the end of the quarter during which the individual was gained.

more than 0 but less 1 year earlier than the beginning of the fiscal year; $\ell = 2, \dots, 30$ indicates that the ADSD at time of gain is more than $\ell-1$ but less than ℓ years earlier; $\ell = 31$ indicates that ADSD is 30 or more years earlier; and $\ell = 32$ indicates the total of $\ell = 0$ through 31.

2. $t = 1, 2, \dots, 8$ represents TRC as measured from the beginning of the fiscal year.³

3. $p = 1, 2, \dots, 9$ represents PG at time of gain.⁴

Let $IF_{y,d,\ell,t,e}$ represent the number of individuals on active duty at the beginning of fiscal year y with $DEM = d$, $LOS = \ell$ ($0 \leq \ell \leq 12$), $TRC = t$, and who are also on active duty (in the same branch and class of service) at the end of the fiscal year with TRC (as of the end of the fiscal year) = e ; and let $IF_{y,\ell,p,q}$ represent the number of individuals on active duty at the beginning of fiscal year y with $LOS = \ell$ ($13 \leq \ell \leq 31$), $PG = p$, and who are also on active duty (in the same branch and class of service) at the end of the fiscal year with PG (as of the end of the fiscal year) = q .

Let $GF_{y,d,\ell,t,e}$ represent the number of individuals gained during fiscal year y with $LOS = \ell$ ($0 \leq \ell \leq 12$) and remaining subscripts as defined for $IF_{y,d,\ell,t,e}$; and let $GF_{y,\ell,p,q}$ represent the number of individuals gained during fiscal year y , $LOS = \ell$ ($13 \leq \ell \leq 31$) with remaining subscripts as defined for $IF_{y,\ell,p,q}$.

Let $IL_{y,d,\ell,t,r}$ represent the number of individuals on active duty at the beginning of fiscal year y with $DEM = d$, $LOS = \ell$ ($0 \leq \ell \leq 12$), $TRC = t$, and who were not on active duty (in the same branch and class of service) at the end of the fiscal year due to reason r ($1 \leq r \leq 4$), where $r = 1$ indicates loss due to attrition, $r = 2$ indicates loss due to reaching EAOS, $r = 3$ indicates loss due to retirement, and $r = 4$ indicates the total of $r = 1$ through 3.

Let $IL_{y,\ell,p,r}$ represent the number of individuals on active duty at the beginning of fiscal year y with $LOS = \ell$ ($13 \leq \ell \leq 31$), $PG = p$, and who were also not on active duty (in the same branch and class of service) at the end of the fiscal year due to reason r , where r is as defined for $IL_{y,d,\ell,t,r}$.

Let $GL_{y,d,\ell,t,r}$ represent the number of individuals gained during fiscal year y , with $LOS = \ell$ ($0 \leq \ell \leq 12$), and the remaining subscripts defined as for $IL_{y,d,\ell,t,r}$; and let $GL_{y,\ell,p,r}$ represent the number of individuals gained during fiscal year y with the remaining subscripts defined as for $IL_{y,\ell,p,r}$.

³TRC = EAOS date-begin FY date where EAOS date is as recorded on the EMR as of the end of the quarter during which the individual was gained.

⁴Specifically, PG as recorded on the EMR as of the end of the quarter during which the individual was gained.

Let $IR_{y,d,\ell,t}$ represent the individuals on active duty at the beginning of fiscal year y with $DEM = d$, $LOS = \ell$ ($0 \leq \ell \leq 12$), $TRC = t$, who reenlisted in the same branch and class of service during the fiscal year; and let $IR_{y,\ell,p}$ represent the number of individuals on active duty at the beginning of fiscal year y with $LOS = \ell$ ($13 \leq \ell \leq 31$), and $PG = p$ who reenlisted in the same branch and class of service during the fiscal year.

Let $GR_{y,d,\ell,t}$ represent the number of individuals gained during fiscal year y with $LOS = \ell$ ($0 \leq \ell \leq 12$) who reenlisted in the same branch and class of service during the fiscal year with remaining subscripts as defined for $IR_{y,d,\ell,t}$; and let $GR_{y,\ell,p}$ represent the number of individuals gained during fiscal year y with $LOS = \ell$ ($13 \leq \ell \leq 31$) who reenlisted in the same branch and class of service during the fiscal year with remaining subscripts as defined for $IR_{y,\ell,p}$.

Let $IB_{y,d,\ell,t}$, $IB_{y,\ell,p}$, $GB_{y,d,\ell,t}$, and $GB_{y,\ell,p}$, be analogous to $IR_{y,d,\ell,t}$, $IR_{y,\ell,p}$, $GR_{y,d,\ell,t}$, and $GR_{y,\ell,p}$, but represent counts of individuals who bonus extended rather than reenlisted.

Let $IP_{y,d,\ell,p,q}$ represent the number of individuals on active duty at the beginning of fiscal year y with $DEM = d$, $LOS = \ell$ ($0 \leq \ell < 12$), $PG = p$, and (1) were on active duty in the same branch and class at the end of the fiscal year with $PG = q$ or (2) were not on active duty in the same branch and class at the end of the fiscal year with $PG = q$ at the time of loss to that branch and class.

Let $IP_{y,\ell,p,q}$ represent the number of individuals on active duty at the beginning of fiscal year y with $LOS = \ell$ ($13 \leq \ell \leq 31$) and remaining subscripts as defined for $IP_{y,d,\ell,p,q}$.

Let $GP_{y,d,\ell,p,q}$ represent the number of individuals gained during fiscal year y with $LOS = \ell$ ($0 \leq \ell \leq 12$) and remaining subscripts as defined for $IP_{y,d,\ell,p,q}$; and let $GP_{y,\ell,p,q}$ represent the number of individuals gained during fiscal year y with $LOS = \ell$ ($13 \leq \ell \leq 31$) and remaining subscripts as defined for $IP_{y,\ell,p,q}$.

ELF consists of two steps:

1. Obtain the values for the matrices described above for one or more selected fiscal years (ELF-ONE).
2. Apply an appropriate statistical procedure to these matrices to obtain the enlisted loss/flow forecast data base (ELF-FORE).

Each step is described below.

ELF Step 1 (ELF-ONE)

The data source for ELF-ONE is the enlisted Survival Tracking File (STF). The STF is longitudinal data base that includes, for each individual, a sequence of quarterly records derived from the enlisted master record (EMR) file. A detailed description of the STF is

contained in NPRDC Technical Note 81-11.⁵ For each individual, ELF obtains the subsequence of records pertaining to the selected fiscal year (i.e., all records relating to the end of the fourth quarter of the previous fiscal year through the end of the fourth quarter of the selected fiscal year). Utilizing this subsequence of records, ELF determines which matrix cells pertain to this individual and increments these cell counts by 1. The elements of these matrices are then combined into four new matrices (FGCL12, FGCUI9, PRML12, and PRMU19).

The sequence of records relating to a given individual and pertaining to a given fiscal year are examined to determine whether the individual was on active duty at the beginning of the fiscal year (i.e., as of the end of the fourth quarter of the previous fiscal year). An individual is in active duty status if an STF record as of the fourth quarter of the previous fiscal year is found and this record does not contain a loss code. All such individuals are counted in matrices with prefix "I" (i.e., on beginning Inventory). Otherwise, the individual is considered to have been a gain to active duty during the fiscal year. These individuals are counted in matrices with prefix "G" (i.e., Gains).

Next, an assessment is made as to whether the individual (1) was on active duty in the same branch and class of service at the end of the fiscal year or (2) had been lost to the branch and class during the fiscal year. This is done by checking whether a change of branch and class of service occurred during the fiscal year. Such a change is considered to have taken place when the sequence of records contains a record with term status = "Z" followed by a record with term status $\neq$ "Z" (indicating a change from USNR to USN) or a record with term status $\neq$ "Z" followed by a record with term status = "Z" (indicating a change from USN to USNR). When such a branch/class change has occurred, the individual is considered a loss (due to reaching EAOS) from the original branch and class and a gain to the subsequent branch and class.

If no change in branch and class has been found, an assessment is made as to whether the individual was on active duty at the end of the fiscal year. An individual is considered to have been on active duty at the end of the fiscal year if an STF record as of the fourth quarter of the fiscal year is found and does not contain a loss code. All individuals on active duty at the end of the fiscal year are counted in matrices ending in "F" and "P" (i.e., Flow and Pay grade changes). For individuals lost during the fiscal year, the specific reason is obtained from the last record with the original branch and class. Losses are categorized by DoD loss code/SPD code. These codes are aggregated to represent 3 types of losses: attrition, end of obligated service, and retirement. Such individuals are counted in matrices ending in "L" and "P" (i.e., Losses and Pay grade changes).

Next, a determination is made as to whether the individual reenlisted during the fiscal year. A reenlistment is considered to have taken place when the sequence of records is such that the number of enlistments in the first record is less than the number of enlistments in the last record. Such individuals are counted in matrices ending in "R" (i.e., Reenlistments).

The final calculation determines whether or not the individual extended his current enlistment contract by 24 months or more. A year or "bonus" extension is determined to have taken place if (1) the individual did not reenlist during the fiscal year and (2) the value in the term status field is greater in the individual's last record of the fiscal year than in the first. Such individuals are counted in matrices ending in "B" (i.e., Bonus Extensions).

⁵Gay, K. W., & Borack, J. I. The Enlisted Survival Tracking File (NPRDC Technical Note 81-11) San Diego: Navy Personnel Research and Development Center, April 1981.

When the above processing has been completed for the selected fiscal year y , the elements of the matrices are combined into four new matrices:

1. FGCL12 (i, d, ℓ, t, j)
2. FGCU19 (i, ℓ, p, k)
3. PRML12 (i, d, ℓ, p, q)
4. PRMU19 (i, ℓ, p, q)

The subscripts of these four matrices are defined as follows:

i indicates whether the data pertain to individuals on active duty at the beginning of the fiscal year ($i = 1$) or individuals gained during the fiscal year ($i = 2$); $i = 3$ represents the total of $i = 1$ and $i = 2$.

d indicates the demographic group with values as defined for $I(y, d, \ell, t, p)$ when $i = 1$; and as defined for $G(y, d, \ell, t, p)$ when $i = 2$.

ℓ indicates length of service. For matrices ending in "12," $\ell = 1, 2, \dots, 13$ are as defined for $I(y, d, \ell, t, p)$ when $i = 1$ and as defined for $G(y, d, \ell', t, p)$ when $i = 2$, where $\ell = \ell' + 1$. $\ell = 14$ is the total of $\ell = 1, 2, \dots, 13$.

For matrices ending in "19," $\ell = 1, 2, \dots, 19$ are as defined for $I(y, \ell, p)$ when $i = 1$ and as defined for $G(y, \ell', p)$ when $i = 2$, where $\ell = \ell' - 12$. $\ell = 20$ is the total of $\ell = 1, 2, \dots, 19$.

t indicates time remaining on contract with values as defined for $I(y, d, \ell, t, p)$ when $i = 1$ and as defined for $G(y, d, \ell, t, p)$ when $i = 2$.

p indicates pay grade with values as defined for $I(y, d, \ell, t, p)$ when $i = 1$ and as defined for $G(y, d, \ell, t, p)$ when $i = 2$.

q indicates pay grade with values as defined for $IP(y, d, \ell, p, q)$ when $i = 1$ and as defined for $GP(y, d, \ell, p, q)$ when $i = 2$.

j indicates particular personnel flows. $j = 1, \dots, 6$ indicates active duty status at end of fiscal year with time remaining on contract as defined for $IF(y, d, \ell, t, j)$ when $i = 1$ and as defined for $GF(y, d, \ell, t, j)$ when $i = 2$; $j = 9, 10, 11$ indicates loss to branch and class during fiscal year for reason $r = 1, 2, 3$ as defined for $IL(y, d, \ell, t, r)$ when $i = 1$ and as defined for $GL(y, d, \ell, t, r)$ when $i = 2$; $j = 12$ indicates reenlistment during the fiscal year, and $j = 13$ indicates bonus extensions during the fiscal year; $j = 8$ is the sum of $j = 9, \dots, 11$ and represents all losses during the fiscal year. $j = 7$ is the sum $j = 1, \dots, 6, 8$ and represents the begin fiscal year inventory ($i = 1$) or the fiscal year gains ($i = 2$).

k indicates particular personnel flows for $LOS > 13$. $k = 1, \dots, 9$ indicates active status at end of fiscal year with end fiscal year pay grade as defined for $IF(y, \ell, p, k)$ when $i = 1$ and as defined for $GF(y, \ell, p, k)$ when $i = 2$; $k = 12, 13, 14$ indicates loss to branch and class during fiscal year for reason $r = 1, 2, 3$ as defined for $IL(y, \ell, p, r)$ when $i = 1$ and as defined for $GL(y, \ell, p, r)$ when $i = 2$; $k = 15$ indicates reenlistment during the fiscal year; and $k = 16$ indicates bonus extensions during the fiscal year. $k = 11$ is the sum of $k = 12, 13, 14$ and represents all losses during the fiscal year. $k = 10$ is the sum of $k = 1, \dots, 9, 11$, and represents the begin fiscal year inventory ($i = 1$) or the fiscal year gains ($i = 2$).

The relationship between the elements of the four new matrices and the matrices previously discussed is presented in Table 1. The four matrices are written as four data

Table 1
ELF Matrix Relationship

Matrix	For $i = 1$	For $i = 2$
FGCL12(i, d, l, t, j)	IF(y, d, l, t, j)	GF(y, d, l, t, j)
	$1 \leq j \leq 6$	$1 \leq j \leq 6$
	IL(y, d, l, t, r)	GL(y, d, l, t, r)
	$j = r + 8$	$j = r + 8$
	IR(y, d, l, t)	GR(y, d, l, t)
	IB(y, d, l, t)	GB(y, d, l, t)
FGCU19(i, l, p, k)	IF(y, l, p, k)	GF(y, l, p, k)
	$1 \leq k \leq 9$	$1 \leq k \leq 9$
	IL(y, l, p, r)	GL(y, l, p, r)
	$k = r + 11$	$k = r + 11$
	IR(y, l, p)	GR(y, l, p)
	IB(y, l, p)	GB(y, l, p)
PRML12(i, d, l, p, q)	IP(y, d, l, p, q)	GP(y, d, l, p, q)
PRMU19(i, l, p, q)	IP(y, l, p, q)	GP(y, l, p, q)

sets. The data control block (DCB) characteristics for the output, called ELFOUT, are the same for each data set; namely, LRECL = 131, BLKSIZE = 6550, and RECFM = FB.

The record format for each matrix is shown in Table 2; and an example of the interpretation of a typical record from matrix FGCL12, in Figure 2.

Table 2
ELF Data Base Tape Record Format

Matrix	Data Format	Positions
FGCL12:		
Filler	1X	1
i	I1	2
d	I3	3-5
l	I3	6-8
t	I3	9-11
FGCL12 (i,d,l,t,1)	F8.0	12-19
FGCL12 (i,d,l,t,2)	F8.0	20-27
.	.	.
.	.	.
FGCL12 (i,d,l,t,12)	F8.0	100-107
Filler	F8.0	108-115
Filler	F8.0	116-123
Filler	F8.0	124-131
FGCU19:		
Filler	1X	1
i	I1	2
d	I3	3-5
l	I3	6-8
p	I3	9-11
PRML12 (i,d,l,p,1)	F8.0	20-27
.	.	.
.	.	.
PRML12 (i,d,l,p,10)	F8.0	84-91
Filler	F8.0	92-99
.	.	.
.	.	.
Filler	F8.0	124-131

Length of Service Less than 12 years:

Begin Year:			Begin Inventory	Position at End of Year											
DG	LOS	TRC		<u>Still on ACDU with TRC</u>						<u>Loss Due to</u>					Bonus Ext.
				0<1	1<2	2<3	3<4	4<5	5<6	Attrit	EAOS	Retire	Reenl.		
1	3<4	0<1	7,000	600	1,200	0	2,000	50	150	200	2,800	0	2,200	1,350	

Length of Service more than 12 years:

Begin Year:		Position at End of Year											
LOS	PG	Begin Inventory	<u>Still on ACDU with PG</u>						<u>Loss Due to</u>				Bonus Ext.
			1	2..	6	7	8	9	Attrit	EAOS	Retire	Reenl.	
19<20	8	5,000	0	0	0	100	2,300	600	100	0	1,900	200	110

Figure 2. An example of STEP processing.

The processing in ELF-ONE is repeated for all fiscal years utilized by the forecast methodology described in ELF Step 2. The number of years that may be processed is limited by the time period covered by the survival tracking file. At present, fiscal years 1978, 1979, and 1980 are being utilized.

ELF Step 2 (ELF-FORE)

ELF-FORE analyzes data obtained from step 1 to create the enlisted loss/flow forecast data base (ELFCAST). At present, the forecast data base is obtained by utilizing the following formula:

$$X_f = \frac{X_{78} + X_{79} + X_{80}}{3}$$

where

X = FGCL12, FGCU19, PRML12, or PRMU19
as appropriate

78 = From fiscal year 1978

79 = From fiscal year 1979

80 = From fiscal year 1980

f = Enlisted loss/flow data base

ELFCAST is comprised of the resulting four matrices, which are written as four data sets. The data control block (DCB) characteristics of each data set of ELFCAST are the same as for ELFOUT; that is, LRECL = 131, BLKSIZE = 6,550, RECFM = FB.

EEL Methodology

As stated earlier, EEL supplies forecasts of specified personnel flows to ECO. These personnel flows and their associated subroutines are:

1. Attrition (ATTR)
2. EAOS Losses (EAOS)
3. EAOS Flows (EAOSFL)
4. Gain Attrition (GATTR)
5. Gross Net Gains (GROSNG)
6. Prior-Service Gains (PSGAN)
7. Net Gross Gains (NETGG)
8. Reenlistment (REEN)
9. Bonus Extensions (BONEX)
10. Retirement (RETIR)
11. Advancements In/Out (ADVIO)
12. Demotions In/Out (DEMIO)
13. Gain Advancements In/Out (GADVIO)
14. Gain Demotions In/Out (GDEMIO)

The forecasts are made through a sequence of subroutines that utilize inventories (generated in ECO) and a forecast data base (ELF-CAST) derived from ELF-OUT.

Forecast Data Base

The EEL forecast data base (EEL-RAT) consists of six data sets--FLB, FUB, FLE, FUE, PL, and PU--which contain the data necessary to create personnel flow forecast matrices (required by ECO).

The contents of these data sets consist of estimated flow rates. Operationally, flow rates represent the percentage of individuals with a specific set of characteristics⁶ as of the beginning of the fiscal year (or at the time of gain) who have a specific set of characteristics as of the end of the fiscal year (or who made a specific decision during the year). These flow rates are estimated as follows:

1. For $1 \leq l \leq 12$:

$$ATTR(d, l, t, p) = \frac{FGCL12(1, d, l+1, t, 9)}{FGCL12(1, d, l+1, t, 7)}$$

2. For $13 \leq l \leq 31$:

$$ATTR(l, p) = \frac{FGCU19(1, l-12, p, 12)}{FGCU19(1, l-12, p, 10)}$$

The estimates of the EAOS loss rate (used in EAOS) are:

1. For $1 \leq l \leq 12$:

$$EAOS(d, l, t, p) = \frac{FGCL12(1, d, l+1, t, 10) + FGCL12(1, d, l+1, t, 12)}{FGCL12(1, d, l+1, t, 7)}$$

2. For $13 \leq l \leq 31$:

$$EAOS(l, p) = \frac{FGCU19(1, l-12, p, 13) + FGCU19(1, l-12, p, 15)}{FGCU19(1, l-12, p, 10)}$$

The estimates of the EAOS flow rate into TRC = j' (used in EAOSFL) are:

1. For $1 \leq l \leq 12$:

$$EAOSFL(d, l, t, p, j') = FGCL12(1, d, l+1, t, j') / \sum_{j=1}^6 FGCL12(1, d, l+1, t, j)$$

The estimates of the gain attrition rate (used in GATTR) are:

1. For $1 \leq l \leq 12$:

⁶These characteristics are equivalent to the dimensional variables of the inventory matrices $I(y, d, l, t, p)$ and $I(y, l, p)$.

$$GATTR(d, \ell, t, p) = \frac{FGCL12(2, d, \ell, t+1, 8)}{FGCL12(2, d, \ell, t+1, 7)}$$

2. For $14 \leq \ell \leq 31$:

$$GATTR(\ell, p) = \frac{FGCU19(2, \ell-13, 10, 11)}{FGCU19(2, \ell-13, 10, 10)}$$

3. For $\ell = 13$:

$$GATTR(13, p) = \frac{FGCL12(2, 7, 13, 8, 8)}{FGCL12(2, 7, 13, 8, 7)}$$

The estimates of the gross net gain inflation rate (used in GROSNG) are:

1. For $\ell = 1$:

$$GROSNG(p, t, d) = 1 - \frac{FGCL12(2, d, 1, t+1, 8)}{FGCL12(2, d, 1, t+1, 7)}$$

2. If $GROSNG(p, t, d) = 0$, then:

$$GROSNG(p, t, d) = 1 - \frac{FGCL12(2, d, 1, t+1, 8) - .5}{FGCL12(2, d, 1, t+1, 7)}$$

The estimates of the number of prior-service gains (used in PSGAN) are:

1. For $\ell = 1$:

$$PSGAN(d, \ell, t, p) = 0$$

2. For $2 \leq \ell \leq 12$:

$$PSGAN(d, \ell, t, p) = FGCL12(2, d, \ell, t+1, 7) \cdot \frac{PRML12(2, d, \ell, p, 10)}{PRML12(2, d, \ell, 10, 10)}$$

3. For $\ell = 13$:

$$PSGAN(13, p) = FGCL12(2, 7, 13, 8, 7) \cdot \frac{PRML12(2, 7, 13, p, 10)}{PRML12(2, 7, 13, 10, 10)}$$

4. For $14 \leq \ell \leq 30$:

$$PSGAN(\ell, p) = PRMU19(2, \ell-13, p)$$

5. For $\ell = 31$:

$$\text{PSGAN}(31,p) = \text{PRMU19}(2,18,p) + \text{PRMU19}(2,19,p)$$

The estimates of the net gross gains deflation factor (used in NETGG) are:

$$\text{NETGG}(p,t,d) = \text{GROSNG}(p,t,d)$$

The estimates of the reenlistment rates (used in REEN) are:

1. For $1 \leq l \leq 12$:

$$\text{REEN}(d,l,t,p) = \frac{\text{FGCL12}(1,d,l+1,t,12)}{\text{FGCL12}(1,d,l+1,t,10) + \text{FGCL12}(1,d,l+1,t,12)}$$

2. For $13 \leq l \leq 31$:

$$\text{REEN}(l,p) = \frac{\text{FGCU19}(1,l-12,p,15)}{\text{FGCL19}(1,l-12,p,13) + \text{FGCU19}(1,l-12,p,15)}$$

The estimates of the bonus extension rates (used in BONEX) are:

1. For $1 \leq l \leq 12$:

$$\text{BONEX}(d,l,t,p) = \text{FGCL12}(1,d,l+1,t,13) / \sum_{j=1}^6 \text{FGCL12}(1,d,l+1,t,j)$$

2. For $13 \leq l \leq 31$:

$$\text{BONEX}(l,p) = \text{FGCU19}(1,l-12,p,16) / \sum_{j=1}^9 \text{FGCU19}(1,l-12,p,j)$$

The estimates of the retirement rates (used in RETIR) are:

1. For $1 \leq l \leq 12$:

$$\text{RETIR}(d,l,t,p) = \frac{\text{FGCL12}(1,d,l+1,t,12)}{\text{FGCL12}(1,d,l+1,t,7)}$$

2. For $13 \leq l \leq 31$:

$$\text{RETIR}(l,p) = \frac{\text{FGCU19}(1,l-12,p,15)}{\text{FGCL19}(1,l-12,p,10)}$$

The estimates of the advancement rates from p into p' (used in ADVIO) are:

1. For $1 \leq l \leq 12$:

$$\text{ADVIO}(d,l,p,p') = \frac{\text{PRML12}(1,d,l+1,p,p')}{\text{PRML12}(1,d,l+1,p,10)}$$

2. For $13 \leq l \leq 31$:

$$\text{ADVIO}(l, p, p') = \frac{\text{PRMU19}(1, l-12, p, p')}{\text{PRMU19}(1, l-12, p, 10)}$$

The estimates of the demotion rates from p into p' (used in DEMIO) are the same as for ADVIO.

The estimates of the gain advancement rates from p to p' (used in GADVIO) are:

1. For $1 \leq l \leq 12$:

$$\text{GADVIO}(d, l, p, p') = \frac{\text{PRML12}(2, d, l, p, p')}{\text{PRML12}(2, d, l, p, 10)}$$

2. For $l = 13$:

$$\text{GADVIO}(13, p, p') = \frac{\text{PRML12}(2, 7, 13, p, p')}{\text{PRML12}(2, 7, 13, p, 10)}$$

3. For $14 \leq l \leq 31$:

$$\text{GADVIO}(l, p, p') = \frac{\text{PRMU19}(2, l-13, p, p')}{\text{PRMU19}(2, l-13, p, 10)}$$

4. For $l = 31$:

$$\text{GADVIO}(31, p, p') = \frac{\text{PRMU19}(2, 18, p, p') + \text{PRMU19}(2, 19, p, p')}{\text{PRMU19}(2, 18, p, 10) + \text{PRMU19}(2, 19, p, 10)}$$

The estimates of the gain demotion rates from p to p' (used in GDEMIO) are the same as for GADVIO.

The formulae given above are utilized whenever there were more than 45 observations on which to base the estimate. Since ELF-OUT is based upon the average of 3 years of data, these formulae are applied whenever the denominator is at least 15. Whenever the denominator is less than 15, observations are aggregated in order to obtain at least 45 observations upon which to base the estimate. Details of this aggregation process ("default process") are given in Figure 3.

EEL Forecast Subroutines

The following paragraphs describe the EEL subroutines that produce forecasts of the 14 types of personnel flow discussed above. It should be noted that these subroutines may forecast these flows based on any appropriately arrayed inventory.

1. ATTR is subroutine that forecasts the number of individuals who will be lost due to attrition during a fiscal year from a begin fiscal year inventory. The inventory is arrayed in two matrices analogous to the I matrices described in the ELF methodology

1. When formulae call for PRMU12 or 13:

a. If $d = 1$

- | | | |
|-----|----------------|----------------------------------|
| (1) | First Default | $d = 1 + 3$ |
| (2) | Second Default | $d = 1 + 3 + 5$ |
| (3) | Third Default | $d = 1 + 2 + 3 + 5$ |
| (4) | Fourth Default | $d = 7$ |
| (5) | Fifth Default | (FGCL12 only) $d = 7, \ell = 14$ |

b. If $d = 2$ or 3

- | | | |
|-----|----------------|----------------------------------|
| (1) | First Default | $d = 2 + 3$ |
| (2) | Second Default | $d = 1 + 2 + 3$ |
| (3) | Third Default | $d = 7$ |
| (4) | Fourth Default | (FGCL12 only) $d = 7, \ell = 14$ |

c. If $d = 4$

- | | | |
|-----|----------------|----------------------------------|
| (1) | First Default | $d = 2 + 4$ |
| (2) | Second Default | $d = 2 + 3 + 4$ |
| (3) | Third Default | $d = 7$ |
| (4) | Fourth Default | (FGCL12 only) $d = 7, \ell = 14$ |

d. If $d = 5$

- | | | |
|-----|----------------|----------------------------------|
| (1) | First Default | $d = 1 + 3 + 5$ |
| (2) | Second Default | $d = 7$ |
| (3) | Third Default | (FGCL12 only) $d = 7, \ell = 14$ |

e. If $d = 6$

- | | | |
|-----|----------------|----------------------------------|
| (1) | First Default | $d = 2 + 3 + 4 + 6$ |
| (2) | Second Default | $d = 7$ |
| (3) | Third Default | (FGCL12 only) $d = 7, \ell = 14$ |

2. When formulae call for PRMU19:

- | | | |
|----|----------------|--|
| a. | First Default | $\ell' = \ell - 1$ through $\ell + 1$ |
| b. | Second Default | $\ell' = \ell - 2$ through $\ell + 2$ etc. |

3. When formulae call for FGCU19, First Default $p = 10$

4. When developing data for PSGAN, no default is used.

Figure 3. Details of default process.

section (i.e., $I(y,d,l,t,p)$ for $1 \leq l \leq 12$ and $I(y,l,p)$ for $13 \leq l \leq 31$). ATTR returns two similarly arrayed matrices of attrition losses-- AL_1 and AL_2 . These two matrices of forecasts are the result of the element by element multiplications:

$$AL_1(d,l,t,p) = ATTR(d,l,t,p) \cdot I(y,d,l,t,p)$$

$$AL_2(l,p) = ATTR(l,p) \cdot I(y,l,p).$$

2. EAOS is a subroutine that forecasts the number of individuals who will reach the end of active obligated service (EAOS) during the fiscal year. From begin fiscal year inventories described in ATTR, the forecasts, EL_1 and EL_2 , are the result of :

$$EL_1(d,l,t,p) = EAOS(d,l,t,p) \cdot I(y,d,l,t,p)$$

$$EL_2(l,p) = EAOS(l,p) \cdot I(y,l,p).$$

3. EAOSFL is a subroutine that forecasts the number of surviving individuals who will have a specific TRC j' as of the end of the fiscal year based upon an inventory of surviving individuals, SI, arrayed as in ATTR. The forecasts, EFL_1 and EFL_2 , are the result of:

$$EFL_1(d,l,j',p) = \sum_{t=1}^7 EAOSFL(d,l,t,p,j') \cdot SI(y,d,l,t,p)$$

$$EFL_2(l,p) = SI(l,p).$$

4. GATTR is a subroutine that forecasts the number of individuals who will be lost due to attrition from the individuals gained during the fiscal year. The "gains" are arrayed in two matrices like the G matrices described in the ELF methodology section (i.e., $G(y,d,l,t,p)$ for $1 \leq l \leq 12$ and $G(y,l,p)$ for $13 \leq l \leq 31$, where l represents LOS as of the end of the fiscal year). The forecasts, GAL_1 and GAL_2 are the result of:

$$GAL_1(d,l,t,p) = GATTR(d,l,t,p) \cdot G(y,d,l,t,p)$$

$$GAL_2(l,p) = GATTR(l,p) \cdot G(y,l,p).$$

5. GROSNG is a subroutine that forecasts the number of gains necessary to produce a specific number of surviving gains, based on a matrix of surviving gains arrayed like SG (p,t,d), where PG = p, TRC = t, DEM = d. The forecasts, GNG, are the result of:

$$GNG(p,t,d) = GROSNG(p,t,d) \cdot SG(p,t,d)$$

6. PSGAN is a subroutine that forecasts the number of individuals who will be gained during a fiscal year with LOS greater than 1 as of the fiscal year. The forecasts, PSG_1 and PSG_2 , are the result of:

$$PSG_1(d, l, t, p) = PSGAN(d, l, t, p)$$

$$PSG_2(l, p) = PSGAN(l, p).$$

7. NETGG is a subroutine that forecasts the number of surviving gains based on a matrix of gains, NG (p,t,d) PG = p, TRC = t, d = DEM. The forecasts, NGG, are the result of:

$$NGG(p, t, d) = NETGG(p, t, d) \cdot NG(p, t, d)$$

8. REEN is a subroutine that forecasts the number of individuals who will reenlist in the same branch and class of service during the fiscal year based on inventories of individuals reaching EAOS during the fiscal year, arrayed as EL_1 and EL_2 (as described in EAOS). The forecasts, R_1 and R_2 , are the results of:

$$R_1(d, l, t, p) = REEN(d, l, t, p) \cdot EL_1(d, l, t, p)$$

$$R_2(l, p) = REEN(l, p) \cdot EL_2(l, p)$$

9. BONEX is a subroutine that forecasts the number of individuals who extend their contact for 2 or more years, based on the surviving inventory. The forecasts, BE_1 and BE_2 , are the result of:

$$BE_1(d, l, t, p) = BONEX(d, l, t, p) \cdot SI(y, d, l, p)$$

$$BE_2(l, p) = BONEX(l, p) \cdot SI(y, l, p)$$

10. RETIR is a subroutine that forecasts the number of individuals lost due to retirement during the fiscal year based on a begin fiscal year inventory as in ATTR. The forecasts, RT_1 and RT_2 , are the result of:

$$RT_1(d, l, t, p) = RETIR(d, l, t, p) \cdot I(y, d, l, t, p)$$

$$RT_2(l, p) = RETIR(l, p) \cdot I(y, l, p).$$

11. ADVIO is a subroutine that forecasts the number of individuals who will advance from pay grades E-1 and E-2 during the fiscal year and the number of individuals who will advance into E-2 and E-3 during the fiscal year based on begin fiscal year inventory arrayed as for ATTR. The forecasts, AF_1 , AF_2 , AT_1 , and AT_2 , are the result of:

For $p = 1, 2$:

$$AF_1(d, l, t, p) = \sum_{p'=p+1}^9 ADVIO(d, l, p, p') \cdot I(y, d, l, t, p)$$

$$AF_2(l,p) = \sum_{p'=p+1}^9 ADVIO(l,p,p') \cdot I(y,l,p)$$

For $p > 2$:

$$AF_1(d,l,t,p) = 0$$

$$AF_2(d,l,t,p) = 0$$

$$AT_1(d,l,t,2) = ADVIO(d,l,1,2) \cdot I(y,d,l,t,1)$$

$$AT_2(l,2) = ADVIO(l,1,2) \cdot I(y,l,1)$$

$$AT_1(d,l,t,3) = \sum_{p=1}^2 \sum_{p'=3}^9 ADVIO(l,p,p') \cdot I(y,d,l,t,p)$$

$$AT_2(l,3) = \sum_{p=1}^2 \sum_{p'=3}^9 ADVIO(l,p,p') \cdot I(y,l,p)$$

For $p > 3$:

$$AT_1(d,l,t,p) = 0$$

$$AT_2(l,p) = 0$$

12. DEMIO is subroutine that forecasts the number of individuals who will be demoted into each pay grade and the number who will be demoted from each pay grade during the fiscal year based on a begin year inventory arrayed as in ATTR. The forecasts, DF_1 DF_2 DT_1 and DT_2 , are the result of:

For $p > 1$:

$$DF_1(d,l,t,p) = \sum_{p'=1}^{p-1} ADVIO(d,l,p,p') \cdot I(y,d,l,t,p)$$

$$DF_2(l,p) = \sum_{p'=1}^{p-1} ADVIO(l,p,p') \cdot I(y,l,p)$$

For $p = 1$:

$$DF_2(l,1) = 0$$

For $p < 9$:

$$DT_1(d,l,t,p) = \sum_{p'=p+1}^9 ADVIO(d,l,p',p) \cdot I(y,d,l,t,p')$$

$$DT_2(l,p) = \sum_{p'=p+1}^9 ADVIO(l,p',p) \cdot I(y,l,p')$$

For $p = 9$:

$$DT_1(d, l, t, 9) = 0$$

$$DT_2(l, 9) = 0$$

13. GADVIO AND GDEMIO are subroutines that forecast the same flows as ADVIO and DEMIO except they are based on an inventory of fiscal year gains. The forecasts are the result of the same formulae as for ADVIO and DEMIO but utilize GADVIO and GDEMIO rates.

Linkage/Integration to STRAP

STEP is presently linked to STRAP, as shown in Figure 4. The subroutines previously discussed are called by ECO whenever forecasts of the aforementioned personnel flows are required. Depending upon the specific type of flow desired, ECO supplies begin fiscal year inventory, surviving inventory, gain inventory, etc., as discussed in the previous section.

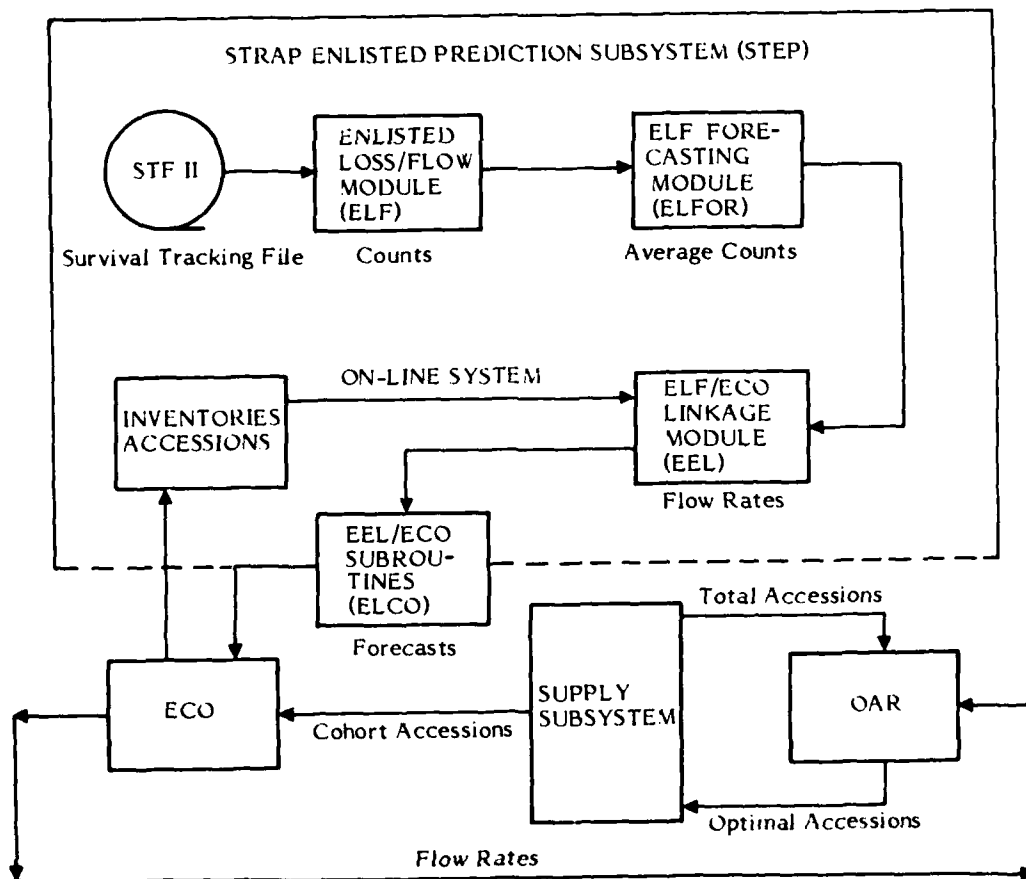


Figure 4. STRAP system: Personnel prediction interface.

CONCLUSION

STEP has been successfully integrated into a prototype STRAP system. This system, including the STEP module discussed in this report, is currently operational on an IBM 370/168 system at the National Institute of Health Central Computer Center, Bethesda, Maryland.⁷ All inputs required by STEP are updated quarterly.

FUTURE PLANS

Further development will be devoted to improvements and extensions of the forecasting methodology discussed in this report. This work will focus on the inclusion of additional variables and the use of statistical forecasting techniques, such as time series analysis, that could be employed as the STF data base expands in both the time period covered and the data elements included.

Additionally, the STEP system will be enhanced so that ELFCAST can incorporate the effects of changes in management policies. This addition will improve the ability of the STRAP system to aid policy-makers in analyzing the trade-offs resulting from management decisions (e.g., policies to lower attrition, increase reenlistment, etc).

⁷A listing of all computer programs utilized in STEP is available upon request from either Kenneth Gay (NMPC-164) or Dr. Jules Borack (NPRDC).

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