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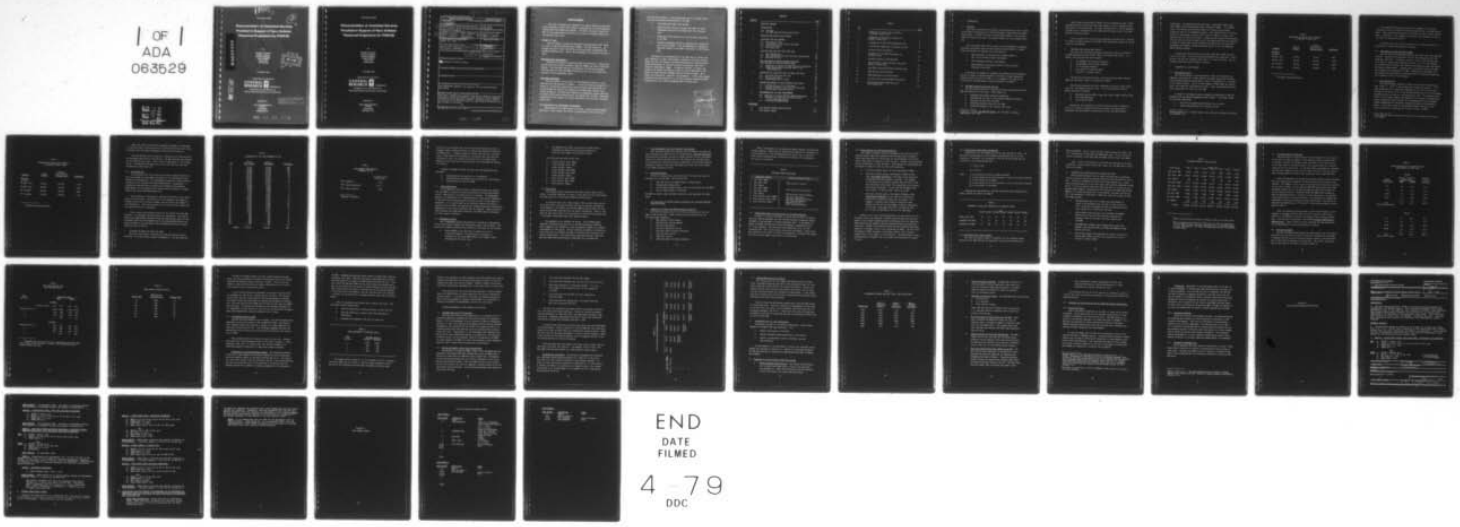

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Final Report CR-228

Documentation of Analytical Services Provided in Support of Navy Enlisted Personnel Projections for POM-80

By:

Kenneth A. Goudreau
Edward J. Schmitz,
Principal Investigator
Peter B. McWhite
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Geraldine Sica

31 October 1978

OPERATIONS ANALYSIS GROUP

GENERAL RESEARCH CORPORATION

A SUBSIDIARY OF FLOW GENERAL INC.

7655 Old Springhouse Road, McLean, Virginia 22102

Submitted To:

Chief of Naval Operations
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This report documents the technical work General Research Corporation performed to assist CNO OP-901M in preparing the FY 80 Navy Manpower Program Objectives Memorandum (POM-80). Recommendations to improve the accuracy of the Enlisted Projection Model used by OP-901M in the POM process are included.

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EXECUTIVE SUMMARY

This report documents the technical work General Research Corporation (GRC) performed to assist CNO OP-901M in preparing the FY 80 Navy Manpower Program Objectives Memorandum (POM-80). The POM is the Navy's annual update of its program needs and serves as the basis for budget requests for the upcoming fiscal year.

SUMMARY OF TASKS

GRC was tasked to operate the Enlisted Projection Model (EPM) which is a part of the Naval Resource Model (NARM). The EPM projects the end strength required to meet the POM force structure space requirements and estimates manpower costs. GRC's tasks encompassed the following two major areas.

EPM Methodology Improvements

The EPM was modified to separately model the attrition of high school and non-high school degree graduates (HSDG and NHSDG) and that of males and females. This permitted explicit incorporation of first-term enlisted attrition goals for HSDG and NHSDG personnel as well as end strength projections for each demographic group.

Data Base Development

With the support of the Bureau of Naval Personnel (Pers-3), a new EPM data base was developed to reflect enlisted loss behavior during FY 77. Errors in a previously prepared data extract routine were identified and corrected when the extract was compared to published Navy military personnel statistics. The data were organized by demographic groups, modified to reflect first-term attrition goals, and entered into the EPM. Additional modifications were required to provide consistency with the Pers-2 enlisted projections.

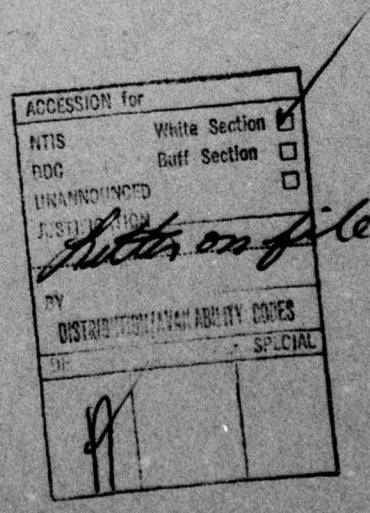
EPM SHORTCOMINGS AND RECOMMENDED IMPROVEMENTS

Shortcomings of the EPM reduce its accuracy, require extensive manual generation of data inputs, and inhibit correspondence checks with Pers-2

loss and gain estimates. Some deficiencies can be corrected by the following recommended modifications to the EPM:

- Automating data input into the EPM.
- Using different recruit training loss rates for each demographic group vice the single loss rate currently used.
- Using active duty service date vice pay entry base date in the EPM.
- Formally validating the EPM by comparing past projections with actual outcomes. This recommendation is singularly important because of the NARM's importance in POM development.

The above ad hoc modifications to the EPM will not correct its poor capability to model reenlistments, extensions, and prior service gains; nor will they prevent the NARM methodology from inducing significant fluctuations in enlisted accession requirements when force structure requirements change. A potential solution to correct the former is to replace the EPM with either the Pers-2 Mini-FAST or the Center for Naval Analyses PROPHET Enlisted Projection Model. Both models are operational, validated, and documented. A first step towards correcting the latter problem is to evaluate accession smoothing methodologies such as the linear programming model the Army uses.



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1 INTRODUCTION

1.1 Overview

This report describes the principal tasks performed by GRC to assist CNO OP-901M in preparing the FY 80 Navy Manpower Program Objectives Memorandum (POM). The POM is the Navy's annual major update of its program needs and serves as the basis for budget requests for the upcoming fiscal year.

GRC's principal effort was to assist in the development of enlisted personnel projections using the Naval Resource Model (NARM) for POM-80. These projections are important for three reasons:

a. They determine the enlisted end strength needed to meet force structure space requirements.

b. They determine accession requirements.

c. They determine the enlisted portion of Navy military personnel costs (MPN).

This report is intended to document the technical work performed by GRC and to assist operating personnel in OP-901M in making subsequent enlisted projections with the NARM. It is designed to be used in conjunction with the NARM manuals already developed by OP-901M.[1]

1.2 The NARM Enlisted Projection Process

The major steps involved in producing enlisted projections with the NARM are described in this paper. These steps are:

- Obtaining the initial enlisted inventories.
- Checking the validity of the enlisted inventory extracts.
- Entering the data into the NARM.
- Entering accession plans into the NARM.
- Making adjustments to the initial loss rates.

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[1] Virginia O. Sielen, The NARM MPN Models, CNO (OP-901M1), Internal Memorandum, March 1978.

These steps are described in detail in the following sections. Where problems that have been encountered seem likely to recur, suggestions have been given for their solution. The paper concludes with a section summarizing GRC's major recommendations for improving the capabilities of the NARM Enlisted Projection Model.

GRC is grateful for the advice and assistance provided by Ms. Virginia O. Sielen, a former analyst with OP-901M, both during the project and in the review of this report.

2 OBTAINING THE INITIAL DATA EXTRACT

The input data describing enlisted inventories, gains and losses for the NARM Enlisted Projection Model (EPM) are obtained from Pers-3. For POM-80, the following data were required:

- 30 September 1977 enlisted inventory
- 30 September 1976 enlisted inventory
- FY 77 returned deserters
- All other FY 77 enlisted gains
- Total FY 77 enlisted losses

The data were extracted by Pers-3 from the Enlisted Master Records (EMR) and the monthly audit of transactions (AMON).

The enlisted personnel data were separated by contract group, education, sex, and length of service (LOS). The following three contract groups were used for POM-80:

- Non-prior service (NPS) 2-year and 3-year obligors (2YO and 3YO)
- All other NPS gains
- Prior service gains

Because of the institution of attrition goals, based on education, as well as a desire to improve projection accuracy, GRC was tasked to incorporate sex and education characteristics into the NARM enlisted

projections. Two education groups were used: high school degree graduates (HSDG) and non-high school degree graduates (NHSDG). The combinations of two sexes, two education groups, and three contract groups produced a total of 12 demographic groups. This required Pers-3 to either modify the data extract routine that it used for POM-79 or write a new computer code (it chose the latter). Because of the limited time available from the start of the GRC contract until the NARM projections were required, it might be argued that incorporating sex and education could have been postponed until POM-81, thereby permitting Pers-3 to use its validated POM-79 extract program.

The EPM uses LOS determined by Pay Entry Base Date (PEBD) and contains 31 LOS cells. Cell One contains individuals with less than 1 year's service, and Cell Two contains those with 1 to 2 year's service. Cell 31 contains those with over 30 years of service.

3 VALIDATING THE DATA EXTRACT

3.1 Data Extract Error

The initial extract of enlisted gains, losses, and inventory was compared to published FY 77 Navy Military Personnel Statistics[1] and data from the BuPers Enlisted Plans Branch. Table 1 illustrates the inaccuracy of the initial extract. The FY 77 end strength is 9000 under the correct total, and losses are overestimated by 6260. These discrepancies made the data unacceptable for input into the NARM.

A review of the computer extract program was undertaken by GRC and personnel from the BuPers Management Science Branch. Two primary causes of error were identified:

- The official program specifications were incorrect
- Reserve personnel were not properly counted

[1] NAVPERS 15658(A), FY 77 Annual Report, Naval Military Personnel Statistics, 30 September 1977.

TABLE 1

COMPARISON OF INITIAL PERS-3 EXTRACT
TO NAVPERS 15658(A) DATA

Category	Initial Extract	Official Navy Enlisted Personnel Data	Difference
Enlisted inventory			
30 Sept. 1977	452,554	461,571	-9017
30 Sept. 1976	462,366	459,707	2659
FY 77 Gains*	125,283	126,887	-1604
FY 77 Losses	128,546	122,286	6260

* Includes returned deserters.

The program specifications are given in Appendix A. They were originally written in October 1976 and no longer reflect the NARM requirements. These specifications should be rewritten to state current requirements. Otherwise, if any changes are required, the programmer is likely to modify the program incorrectly.

Reservists were not properly counted by the original program and a program error caused overestimation of losses.

3.2 Availability of End Fiscal Year EMRs

Once the extract program modifications were made, other data problems surfaced. Neither the 30 September 1976 nor the 30 September 1977 EMR tapes were available.[1] Therefore, the FY 77 and FYTQ end strengths had to be derived, rather than extracted directly. The FY 77 end strength was derived from the October 1977 EMR by subtracting the gains and adding the losses during October. Theoretically, this should produce the same end strength as the September 1977 EMR. Similarly, the September 1976 end strength was calculated by subtracting the FY 77 gains and adding the FY 77 losses to the FY 77 end strength.

3.3 Data Verification

The resulting data compared favorably with the official Navy data (see Table 2). The FY 77 end strength and losses were accurate. FY 76 end strength and FY 77 gains were somewhat low, but this is not as significant as the errors in FY 77 end strength, because the FY 76 end strength was merely used as a base for calculating loss rates. The potential error (2782) in FY 76 would produce rate difference of, at most, 0.6% and would cause a projection error of about 700 in estimating FY 78 end strength. Further examination of the extract routine may improve its estimate of gains. In any case, the FY 77 end-strength figures can serve as an accurate basis for calculating the rates to be used in POM-81.

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[1] These EMRs had been destroyed some time after the original data extract was created.

TABLE 2

COMPARISON OF FINAL PERS-3 EXTRACT
TO NAVPERS 15658(A) DATA*

Category	Final Extract	Official Navy Enlisted Personnel Data	Difference
Enlisted inventory			
30 Sept. 1977	461,303	461,571	- 268
30 Sept. 1976	456,925	459,707	- 2782
FY 77 Gains*	125,244	126,887	- 1643
FY 77 Losses	122,182	122,286	- 104

* Includes returned deserters.

Since the totals in the extract appeared reasonable in comparison to other Navy data, the next step was to verify that the data were being classified into the proper demographic groups and LOS categories.

The most detailed data available for comparison were published Navy end strengths broken down by sex and LOS. The EMR extracted data matched official figures quite well. Table 3 gives a comparison of end strength by LOS. The greatest discrepancy was in the first LOS cell, and that difference was less than 0.4%.

3.4 Chi-Square Test

The chi-square test can be used as an index to measure dispersion. This test assumes an independent distribution of the measurement error between two distributions. The independence assumption is most probably violated for the distributions being examined here. Consequently, a statistical test would not be rigorous for different distributions. Nevertheless, the chi-square values computed here can serve as a useful index of how close the distributions are.

The chi-square is calculated by taking the deviation of each observation from the actual. The deviation is then squared, each square is divided by the actual (official) number, and the results are summed for all observations. The closer the result is to zero, the more likely the two distributions are in agreement.

Table 4 gives the chi-square scores for the initial and final EMR extracts. In all cases, each LOS cell was an observation. The initial extract was significantly different from the official Navy data, but the chi-square score for the inventory after the program modifications compared favorably to the chi-square error determined from the FY 76 data used last year for POM-79.

4 ADJUSTING THE DATA FOR INPUT INTO NARM

The Pers-3 data extract produces card decks and printed reports. The format of the data cards is given in Appendix B. The card deck was

TABLE 3

A COMPARISON OF FY77 END STRENGTHS BY LOS

LOS	Official Navy Figures	Pers-3 EMR Extract	Difference
0	74,139	74,408	- 269
1	75,207	75,043	164
2	66,289	66,150	139
3	44,922	44,848	74
4	20,527	20,481	46
5	21,264	21,241	23
6	16,933	16,926	7
7	15,595	15,583	12
8	14,489	14,493	- 4
9	11,617	11,613	4
10	8,289	8,292	- 3
11	8,238	8,234	4
12	8,859	8,863	- 4
13	7,609	7,602	7
14	7,131	7,130	1
15	7,851	7,851	0
16	8,797	8,797	0
17	9,489	9,493	- 4
18	8,934	8,925	9
19	7,048	7,031	17
20	4,513	4,500	13
21	3,995	3,984	11
22	3,425	3,420	5
23	1,923	1,917	6
24	1,142	1,141	1
25	1,108	1,107	1
26	647	644	3
27	283	283	0
28	290	290	0
29	420	417	3
30	160	160	0
31+	438	436	2
TOTALS	461,571	461,303	268

TABLE 4

A CHI-SQUARE COMPARISON OF
INVENTORY BY LOS

	Chi-Square Score (30 d.f.*)
1976 Inventory	1.03
1977 Initial Inventory	317.73
1977 Final Inventory	2.09

*Degrees of freedom.

difficult to use because there is no Force Level Analysis Interactive Language (FLAIL) program available to convert the card-deck format into the NARM format. A program should be written that takes the card-deck format, makes simple data adjustments, calculates loss rates and gain distribution rates, and produces an output file in the NARM format. Otherwise, over 1100 hand calculations have to be performed and checked for accuracy.

Lacking a program to modify the data, the following steps were necessary:

a. Determining how the data are to be organized.
b. Performing data adjustments and attrition rate calculations.
c. Entering the data into the NARM.

4.1 Data Organization

It was important that the data be organized properly and entered into the NARM in a manner that would facilitate any future data manipulation. Specifically, two issues had to be resolved. The demographic groups to be modeled had to be identified and a "float group" designated. A float group is an enlisted group that does not have a fixed number of accessions. It is used to make up any shortfall between the fixed accessions (such as HSDGs) and required end strength and permits simultaneous computation of both total accessions and end strengths. BuPers accession plans determine the NARM fixed accessions; the NARM computer determines the float group's accessions.

4.1.1 Demographic Groups

The 12 demographic groups (see Section 2) include all combinations of the three contract groups, two educational levels, and two sexes. The partition of women by education was dropped at this point for two reasons:

- Female NHSDGs in the data base accounted for only 4% of enlisted females. This proportion is expected to increase, but the total NHSDG females will remain a small percentage of the total force.

- The NARM EPM can accept no more than 10 model groups; combining the female education groups appeared to have the least impact on projection accuracy.

The resulting nine model groups were:

a. 3-year obligor, male, NHSDG
b. 3-year obligor, male, HSDG
c. 3-year obligor, female
d. 4-year obligor, male NHSDG
e. 4-year obligor, male, HSDG
f. 4-year obligor, female
g. Prior service, male, NHSDG
h. Prior service, male, HSDG
i. Prior service, female

4.1.2 Float Group

Even though initial projections were made without using a float group, it was more efficient to select a float group at this time because the data input for a float group differs from the others.

In previous years, the 4-year obligor (4YO) contract group was the float group since this was the group that had the greatest fluctuation in enlistments. For POM-80, the 4YO male NHSDG group was made the float group because NHSDG enlistees were not supply constrained. That is, the Navy can more easily adjust its recruitment of non-high school males than of the supply constrained high school graduate males.

This approach is not without its faults. The 4YO NHSDG males nominally constitute only about 15% of the NPS accessions; therefore, small changes in end strength can cause substantial changes in accession requirements for this group. Had the time been available, an alternative would have been to reprogram the NARM to distribute NPS accessions into several float groups. This would permit separate modeling of male 4YO HSDG and NHSDG while maintaining a reasonable ratio between them.

4.2 Data Adjustments and Attrition Rate Calculations

Once the model groups were defined, data adjustments were made and rates calculated as specified in the OP-901M report, The NARM MPN Models. One additional adjustment was made by adding enlisted officer candidates (OCs) to the initial starting year (FY 78) inventory for 4YO HSDG males. If additional data had been available, female OCs could have been entered separately; however, this small adjustment would have had little impact on the NARM projection accuracy.

4.3 Entering the Data

After all rates had been hand calculated, the data were ready for entering into the NARM EPM. The procedure was:

a. Code the data in the NARM format on coding sheets

b. Keypunch the coding sheets

c. At the NAVIC computer center, enter the card deck into the NARM

d. Run the update phase of the model

The NARM is ready to make enlisted projections upon completion of these steps.

5 THE ALLOCATION OF BUPERS-PLANNED ACCESSIONS INTO THE NARM ENLISTED PROJECTION MODEL

5.1 Comparison of BuPers and NARM Accession Categories

The BuPers accession plans for FY 78-84 must be entered into the NARM to make projections. These accessions were separated into the following eight categories:

a. USN non-prior service males

b. USN non-prior service females

c. USN prior USN service

d. USN prior USNR/other service

e. USN other gains (returned deserters)

f. USNR non-prior service

g. USNR prior service

h. USNR other gains (returned deserters)

Table 5 illustrates how the BuPers and NARM accession classification schemes compared. BuPers did not specifically break out 3YO accessions by sex or education; it did distinguish 4YOs by sex but not by education. Prior service accessions were classified according to five categories, but not sex or education.

TABLE 5

ACCESSION GROUP EQUIVALENTS

NARM Model Groups	BuPers Accession Groups
1. 3YO, male, NHSDG	USNR non-prior service
2. 3YO, male, HSDG	
3. 3YO, female	
4. 4YO, male, NHSDG	USN non-prior service males
5. 4YO, male, HSDG	
6. 4YO, female	USN non-prior service females
7. Prior service, male, NHSDG	USN prior USN service USN prior USNR/other service USN returned deserters
8. Prior service, male, HSDG	
9. Prior service, female	USNR prior service USNR returned deserters

5.2 Transforming BuPers Accession Data to the NARM Categories

In order to allocate the BuPers accession data for 3YOs, 4YO males, and prior service personnel into the sex and education categories used by the NARM, it was necessary to obtain additional data. To determine the number of female 3YO and prior service accessions, accession data for FY 77 were analyzed. The historical data showed that 3% of all 3YO accessions and 1.6% of prior service accessions were female. These rates were applied to the totals for those two categories to determine 3YO female and prior service female accessions for the POM years.

5.2.1 Three Methods for Allocating Accessions

Once female accessions had been determined, male accessions were divided between high school graduates and non-high school graduates. BuPers had established an overall goal for the percentage of non-prior service HSDG males it expects to enter the Navy. However, this percentage was not broken down for 3YOs and 4YOs. Three methods for determining the percentage of HSDGs for 3YOs and 4YOs were considered:

A. Give each contract group the same percentage of HSDGs.

B. Give each contract group a percentage of HSDGs so that their percentage difference is the same as the historical percentage difference between the groups. For example, if the historical difference between 3YOs and 4YOs is 10%, this difference would remain 10%, regardless of the overall high school percentage. If the 3YOs are 40% HSDG, 4YOs will be 50%. If 3YOs are 80%, 4YOs will be 90%.

C. Give each contract group a percentage of HSDGs so that proportional difference is the same as the historical proportional difference between the two groups. For example, a constant ratio (based on historical data) between the 3YO and 4YO percentages of HSDG is maintained. In this case, 3YOs might have 80% of the HSDG of 4YOs. So, if 3YOs are 80% HSDGs, 4YOs will be 100% HSDGs.

Methods B and C will yield approximately the same results for the accession levels and percentage of HSDGs being projected for the Navy. Method C will produce slightly greater differences above the historical HSDG proportion and slightly smaller differences below the historical proportion. Method C was selected because the 4YO accessions were more sensitive to changes in the overall percentage of HSDGs. As the overall percentage of HSDGs increases or decreases, Method C will allocate slightly more of the change to 4YO accessions. This method more closely approximated the procedure that occurs when 4YO accessions are allowed to float.

5.2.2 Calculating Proportional Differences

Historically, in 1977 HSDGs were 59% for 3YOs and 64% for 4YOs. The historical relationship for the 3YO HSDG proportion was 92% of the 4YO proportion. Therefore, the percentage of 3YO and 4YO male HSDGs was calculated from the following equations:

$$R = p_1 R_1 + p_2 R_2$$

$$R_1 = 0.92\ R_2$$

where R is the overall percent of HSDG accessions

p_1 is the proportion of 3YO accessions to total first-term accessions

R_1 is the percent of 3YO HSDGs

p_2 is the proportion of 4YO accessions to total first-term accessions

R_2 is the percent of 4YO HSDGs

Applying this methodology to the HSDG accessions goals established by BuPers yielded the results in Table 6.

TABLE 6

ESTIMATES OF MALE HSDG PERCENTAGES BY CONTRACT GROUP

	Year						
	FY 78	FY 79	FY 80	FY 81	FY 82	FY 83	FY 84
BuPers male HSDG	76	79	74	76	84	70	73
Estimated 3YO HSDG	71	74	69	71	78	65	68
Estimated 4YO HSDG	77	80	75	77	86	71	74

5.2.3 Allocating Prior Service Males

The final calculation needed to determine all the accession inputs required by the NARM EPM was the separation of prior service males into

HSDGs and NHSDGs. Since 1.6% of the prior service group was female, the FY 77 proportions for male HSDG and NHSDG were used. Of the total prior service accessions, 36.6% were male non-HSDGs and 61.8% were male HSDGs.

Table 7 gives the accessions for FY 78-84 as estimated by the above procedures. These accession levels were input into the NARM EPM to determine end strength.

6 CONVERTING OSD ATTRITION GOALS TO NARM LOSS RATES

OSD has specified goals for the total attrition that is permitted for male non-prior service accessions during the first 36 months of active duty. Attrition is measured by active duty cohort groups; e.g., those males entering during FY 78 will have their loss behavior monitored through FY 81. It does not matter what their PEBD year was, or if they were in a delayed-entry program. The goals for FY 78 were 26% for HSDGs and 49% for NHSDGs. For cohorts entering in FY 79 and beyond, the goals are 23% and 44%. The conversion of OSD goals to NARM loss rates had to deal with the following problems:

- OSD guidelines give only a single total percentage of losses to be permitted over the first 3 years of active duty. There was no guidance on what the permissible loss rates should be in a particular LOS cell.
- OSD provided attrition goals for both HSDGs and NHSDGs. BuPers did not have attrition patterns separated by education level at the time rates were entered into the NARM.
- The NARM model allowed only a single recruit loss rate. However, the attrition goals for HSDGs and NHSDGs include recruit attrition.
- OSD attrition goals were expressed in terms of Active Duty Service Date (ADSD); the NARM loss rates had to be calculated in terms of PEBD.

TABLE 7

ACCESSION INPUTS TO THE NARM EPM*

Model group	Fiscal Year 78	79	80	81	82	83	84
3YO, male, NHS	4,219	3,783	4,510	4,220	3,201	5,092	4,656
3YO, male, HSDG	10,331	10,767	10,040	10,330	11,349	9,458	9,894
3YO, female	450	450	450	450	450	450	450
4YO, male, NHS†	14,774	12,265	16,928	14,378	7,227	20,247	16,316
4YO, male, HSDG	49,459	49,060	50,785	48,133	44,396	49,570	46,438
4YO, female	4,691	7,903	9,950	10,540	11,680	13,185	13,185
PS, male, NHS	8,426	7,902	7,902	7,902	7,902	7,902	7,902
PS, male, HSDG	14,205	13,321	13,321	13,321	13,321	13,321	13,321
PS, female	391	367	367	367	367	367	367
TOTALS	106,946	105,818	114,253	109,641	99,893	119,592	112,529

*Figures were derived from BuPers accession plans as of 6 March 1978.

†These accessions were used as a float; that is, they are calculated so as to make the total personnel strength equal to the NARM estimate of total requirements. All other accessions were derived from BuPers strength plans.

6.1 Attrition Goals for Each LOS

The proportion of attrition which occurs during the first 3 years of active duty will have an impact on both enlisted strength and MPN costs. For example, consider two extreme cases, one where all attrition occurs in the first year of the goaled period, and a second where all attrition takes place in the third year. If the Navy adjusts enlistments to maintain the same end strength in each case, the early attrition force will have a lower average length of service, more accessions, and a lower MPN cost.

Table 8 illustrates the historical attrition pattern of Navy recruits. The last column gives the percent of attrition that has occurred in each interval. For example, 34.4% of the total attrition has typically occurred in the first 6 months. At the time the NARM EPM model inputs were being developed, BuPers had not yet developed separate attrition patterns for the two education levels. Therefore, HSDGs and NHSDGs were assumed to have the same proportions of attrition in each time period. By applying these proportions to the attrition goals, it was possible to estimate the percentage of attrition occurring in each time interval. The results of applying this methodology to FY 78 and FY 79 OSD attrition goals are also given in Table 8.

Since the computed attrition goals in Table 8 were based on a percentage of the total attrition over the first 3 years of active duty, they had to be modified to reflect the proportion lost during any given year. This process is described in the OP-901M Internal Memorandum on NARM Operation. Table 9 gives the rates resulting from the application of this methodology to the attrition goals in Table 8.

6.2 Recruit Loss Rates

Because the NARM enlisted projection model permits only one recruit loss rate, the loss rates in Table 9 could not be entered into the NARM. A composite recruit loss rate was used instead, based on the educational mix of male recruits expected in a given year. The recruit loss rates used in the model for FY 78-84 are given in Table 10.

TABLE 8

THE ALLOCATION OF OSD ATTRITION GOALS
OVER MONTHS OF ACTIVE DUTY

FY 78

Months Active Duty	Percent of Recruit Cohort Lost		Percent of Total Attrition
	HSDG	NHSDG	
1-6	8.9	16.9	34.4
7-12	4.6	8.6	17.5
13-24	7.7	14.5	29.6
25-36	4.8	9.0	18.5
Sum (OSD attrition goal)	26.0	49.0	100.0

FY 79

1-6	7.9	15.1	34.4
7-12	4.0	7.7	17.5
13-24	6.8	13.0	29.6
25-36	4.3	8.2	18.5
Sum (OSD attrition goal)	23.0	44.0	100.0

TABLE 9

LOSS RATES DERIVED FROM
OSD ATTRITION GOALS

PEBD LOS cell	Education level			
	HSDG		NHSDG	
FY 1978				
Contract group	3YO	4YO	3YO	4YO
Recruit(0-6 mo)*	0.089	0.089	0.169	0.169
1	.093	.093	.191	.191
2	.076	.076	.175	.175
3	--	.082	--	.217
FY 1979				
Recruit(0-6 mo)*	.079	.079	.151	.151
1	.080	.080	.167	.167
2	.066	.066	.150	.150
3	--	.077	--	.204

*Separate recruit loss rates are estimated here for high school and non-high school graduates. However, the NARM EPM uses only a single recruit loss rate.

TABLE 10

NARM RECRUIT ATTRITION RATES

Fiscal year	NARM Recruit Attrition rate	Percent HSDG
78	0.108	76
79	.094	79
80	.098	74
81	.096	76
82	.091	84
83	.101	70
84	.098	73

The use of a single recruit loss rate created several problems. First, the rate was based on the male attrition goals and did not permit modeling the different recruit attrition of women. This was not considered a serious problem since the women constituted only 6 to 14% of total recruits over the projection period.

A more serious problem was adjustment of the male attrition rates to compensate for the use of a single recruit loss rate. The solution was to adjust the LOS 1 loss rates so that the percentage of recruits surviving to enter the second LOS cell equaled the estimates in Table 8; e.g., the loss rates for male HSDGs were lowered and the rates for NHSDGs were increased. By making such adjustments, end strength estimates for all demographic cohorts beyond the first LOS cell were accurate and aggregate end strengths were correctly estimated for all years.

6.3 Transforming Goals to PEBD

One more problem remained to be corrected. The attrition goals were expressed in active duty service, and the NARM uses PEBD. The delayed-entry program caused some enlistees to appear in a higher PEBD LOS cell than their active-duty LOS cell. The following paragraphs describe the methodology used to correct the attrition goals from active duty service date to PEBD.

Most accessions enter the service in the first LOS cell. However, some proportion of NPS accessions enter in LOS cells 2 through 6. Those entering in LOS cells 3 or greater were few, and were assumed to be reservists going on active duty, or some other atypical category.

Accounting for the Delayed-Entry Program. NPS accessions entering in LOS cell 2 were assumed to be delayed entrants who should experience attrition behavior similar to NPS gains entering LOS cell 1. The historical loss rates reflect a mix of continuers from LOS 1 and delayed entrants and would be inaccurate only if the proportion of accessions that are delayed entrants were expected to change considerably in the outyears of

the POM. Implementing attrition goals creates a problem with using the historical loss rates. When LOS is based on active-duty service date, attrition goals do not apply to anyone beyond the third LOS cell. However, since the EPM uses PEBD for LOS, those people who entered active duty in the second LOS cell should be goaled through the fourth LOS cell. Thus, the historical LOS cell 4 loss rate was not an accurate estimate of the fourth cell loss behavior, and the loss rate had to be adjusted to account for the proportion of delayed entrants still under attrition goals.

Table 11 illustrates the method used to adjust loss rates. The procedure included these steps:

- Find the proportion of delayed entrants in each LOS cell.
- Find the historical or goaled loss rate applicable to each group.
- Determine the composite loss rate for each cell.

TABLE 11

PEBD ADJUSTMENT TO ATTRITION GOALS

PEBD LOS Cell	4YO HSDG (FY 82)	
	Initial	Adjusted
1	0.080	0.080
2	.066	.069
3	.077	.075
4	.782	.632

The example given in Table 11 is for 4YO HSDGs in FY 82. The major loss-rate change was in LOS cell 4, and the change represents the proportion of its population that was under the goaled attrition rates.

Ideally, the estimation of these composite loss rates should have been an iterative process since the proportion surviving to reach each LOS cell changes each time the rates are changed. However, sample calculations found that second-order adjustments had a very minor effect on loss rates.

Once the LOS cell loss rates had been adjusted to reflect delayed entry, the NARM EPM was run using historical loss rates as modified by attrition goals. If accessions or loss rates are adjusted during the POM, it may be necessary to perform a large number of calculations to properly incorporate the adjustments into the cell loss rates.

7 FURTHER ADJUSTMENTS TO THE HISTORICAL LOSS RATES

7.1 Problems with the FY 77 Data Base

The loss rates that had been developed so far reflected the FY 77 historical experience combined with OSD attrition goals for enlistees. However, FY 77 was determined to be an unrealistic base for making projections; it had a very high attrition among non-prior-service personnel. Furthermore, this attrition did not reflect any long-term trend of increasing losses since one-time-only early out policies were in effect during that year. Additionally, it was determined that different year-group cohorts were exhibiting different loss behavior at the same year-of-service point, and this behavior could not be modeled by the NARM. For these reasons, the NARM loss rates were adjusted to reach agreement with the Pers-2 January FYDP accession and loss estimates.

7.2 Forcing the NARM to Match Pers-2 Projections

The process of forcing the NARM to match Pers-2 estimates was complicated by the design difference between Pers-2 and the NARM; Pers-2 data were in ADSD while the NARM data were in PEBD form. Furthermore, the two projection systems were not strictly comparable for loss categories and enlistment groups. Since the NARM and Pers-2 total losses but not loss rates by LOS could be compared, latitude existed in the way loss rates could be modified. The following constraints were imposed to reduce this latitude:

- Loss rates were adjusted only for NPS groups.
- Loss rates were adjusted over only the first five LOS cells.
- Rates were adjusted in a consistent manner. If a rate was changed in one projection year, it was changed in all years.
- Loss rates were not adjusted for cells subjected to attrition goals.
- Loss rates were not reduced below the lowest attrition goal for a particular LOS cell.

The first two constraints were used because the excess attrition in FY 77 occurred in first-term enlistees. These two restrictions merely limited adjustments to those LOS cells that experienced abnormally high loss rates. Consistent adjustments were made to avoid loss rates that arbitrarily increased and decreased from year to year.

In future years, more LOS cells will have their loss rates determined by attrition goals. Table 12 shows for a 4YO the PEBD LOS cells that have either all or part of their loss rate controlled by attrition goals. Where the cell loss rate was goal determined, it was not further adjusted. Where a cell's loss rate was partially goaled, only the ungoaled portion of the cell population had its loss rate adjusted.

Attrition goals were also taken as the lower limit of what a particular cell's attrition rate could be. For example, the FY 78 LOS 1 4YO male HSDG attrition goal served as a lower bound for future years.

Adjusting the Loss Rates. The process of adjustment was iterative. With nine model groups being estimated over 7 years for 31 LOS cells, over 1900 loss rates affected the model's end-strength estimates. Of these, 210 loss rates were candidates for modification. It was difficult to predict the impact of any given set of changes on all of the outyear projections; e.g., an improvement of an estimate in FY 82 could worsen the projection for FY 83.

TABLE 12

LOS CELLS WITH GOAL-DETERMINED ATTRITIONS

	4 Year Obligors						
LOS Cell (PEBD)	FY 78	FY 79	FY 80	FY 81	FY 82	FY 83	FY 84
Recruit (0-6 mo)	Goaled	Goaled	Goaled	Goaled	Goaled	Goaled	Goaled
1		Goaled	Goaled	Goaled	Goaled	Goaled	Goaled
2		Partially goaled	Goaled	Goaled	Goaled	Goaled	Goaled
3			Partially goaled	Goaled	Goaled	Goaled	Goaled
4				Partially goaled	Partially goaled	Partially goaled	Partially goaled

7.3 Judging NARM Projection Accuracy

Two criteria were set for judging the NARM projection accuracy. First, each NARM projection year had to have estimated losses (or float group accessions) within 4000 of the Pers-2 projections. Second, any changes that met this criterion and reduced the absolute sum of losses over all projection years was considered an improvement. A rate adjustment that violated none of the previous constraints and decreased overall differences with Pers-2 was preferred.

Table 13 shows the differences between Pers-2 and the NARM losses for three model runs. After two iterations of adjustments to loss rates in the first four LOS cells, it was determined that loss rates were in reasonable agreement with Pers-2. These loss rates were then used with the NARM as the basis for projecting enlisted end strengths and MPN costs in the FY 80 Navy POM.

8 RECOMMENDATIONS FOR NARM IMPROVEMENTS

During GRC's support to the POM-80 working group, several shortcomings of the NARM's EPM were identified. They

- Reduce the accuracy of the model
- Require extensive manual generation of data inputs
- Inhibit correspondence checks with BuPers loss and gain estimates

The improvements to the EPM needed to correct the individual shortcomings are discussed in Section 8.1. Section 8.2 discusses replacing the EPM and improving or replacing the NARM methodology used to compute end strength.

8.1 Measures to Correct Specific NARM Shortcomings

- Rewrite Program Specifications. The program specifications for the end-of-year EMR extract by Pers-3 are inaccurate (see Appendix A). These specifications should be rewritten so that they reflect the current EPM input needs.

TABLE 13

DIFFERENCES BETWEEN NARM AND PERS-2 LOSS PROJECTIONS

Fiscal Year	Run 1 Unadjusted Rates	Run 2 First Adjustment	Run 3 Second Adjustment
1978	21185	246	52
1979	17063	6741	4427
1980	5021	1852	2925
1981	-4663	-5748	-5233
1982	12925	2688	2608
1983	9808	-25	493
1984	6716	-778	697

- Verify the Extract Routine. Although GRC's analysis of the data extract routine found that a major source of error was improper coding specifications, an in-depth analysis should be attempted to reduce an apparent error in determining gains.

- Redefine the Contract Groups. The NARM EPM models three groups:
  a. 2YOs and 3YOs
  b. 4, 5, and 6YOs
  c. Prior service obligors

  Since 4YOs and 6YOs have different attrition patterns, 4, 5, and 6YOs should be redefined into at least two distinct model groups.

- Facilitate Input of Pers-3 Data into the EPM. Since Pers-3 produced the NARM data extract on a set of computer cards, a program is needed to translate these data into the NARM format. This program would save over 1100 hand calculations and remove many opportunities for error.

- Improve the Recruit Attrition Methodology. The EPM's single recruit loss rate does not accurately model different recruit behavior and/or OSD attrition goals. The EPM should be modified to incorporate a different recruit loss rate for each NARM accession category.

- Use Active Duty Service Date (ADSD) in the EPM. The EPM's use of PEBD contributes to difficulty in incorporating DoD attrition goals and in comparing loss estimates with those of BuPers. Projection accuracy suffers because the delayed-entry program (DEP) mixes different active-duty years of service. The EPM's data base and format could be shifted from PEBD to ADSD

and a translation routine[1] implemented to shift each projected ADSD year of service distribution to a PEBD distribution to permit costing the force.

This approach would be an ad hoc solution to improving projection accuracy but would not provide the benefits of replacing the EPM and the NARM methodology.

8.2 Rationale for Replacing the EPM and NARM End-Strength Methodology

8.2.1 Projection Models

Even if the EPM were modified to use ADSD, it would retain several weaknesses. Chief among these are poor modeling capabilities for reenlistments, extensions, and prior service gains. The NARM would be improved if the EPM were replaced with either Mini-FAST or PROPHET.[2] Mini-FAST has the advantage of being consistent with BuPers projections; PROPHET separately models high school and non-high school graduates and explicitly models extensions and reenlistments.

It could be argued that the EPM could be modified to give it the desired Mini-FAST or PROPHET features. Although probably feasible, adding features such as explicit modeling of extensions and reenlistments would require major modifications. The resulting model might be more complex, more costly, and more difficult to use than a replacement; and Mini-FAST and PROPHET are operational, validated, and documented.

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[1] Methodologies for LOS translation routines are described in: J. I. Borack, "Techniques for Estimating the Cost of Enlisted Personnel Force Structures from Data Categorized by Total Active Federal Military Service," Naval Personnel Research and Development Center, May 1978; M. Chipman, "Forecasting the Naval Enlisted Personnel Force Structure to Estimate Basic Pay," Naval Personnel Research and Development Center, TR 78-4, November 1977.

[2] Mini-FAST is operational at Pers-2; PROPHET is operational at the Center for Naval Analyses.

Validation. Regardless of the improvements made on the EPM, it is sound management to validate any model which plays an important role in decision making. As far as GRC was able to determine, the EPM has not been validated by comparing projections from past years with the actual outcome, yet validation results from past projections would have substantial value in assessing the accuracy of current projections. A validation can be conducted at any time by using EMRs from past years. If Pers-3 has not retained end fiscal year EMRs, it might be possible to use some of the EMRs that the Center for Naval Analyses has retained.

8.2.2. Accession Smoothing

When force structure requirements fluctuate, the NARM methodology for computing end strength can cause significant fluctuations in NPS accession requirements. This could be alleviated by incorporating a capability for accession smoothing. One approach, used by the Army,[1] is to incorporate the methodology for projecting NPS accessions and the end strength required to meet structure space goals in a linear program with an objective function which smooths accessions. This technique permits development of a 5-year manpower program within several hours. Further evaluation of accession smoothing methodologies is recommended.

8.3 Procedural Recommendations

The 30 September EMR tapes should be retained for at least 3 years. Either Pers-3 should be so directed or OP-901M should retain copies of these tapes. Storage requirements could be reduced by creating an EMR extract tape containing only the information required to create the EPM data base.

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[1] Betty W. Holz, et al., "The ELIM-COMPLIP System of Manpower Planning Models, Vol I-General Overview," OAD-CR-18, General Research Corporation, December 1973.

Appendix A

DATA EXTRACT PROGRAM SPECIFICATIONS

DATA PROCESSING SERVICES REQUEST
NAVPERS 5230/34 (Rev. 7-73)

TO BE FILLED OUT IN TRIPLICATE

1: Deputy ACNP Management Information (Pers-3C)

REQUEST NO. 21-053-76

1. FROM (Requesting Office)
Head, Active Enlisted Plans Branch (Pers-212)

2. DATE OF REQUEST
OCT [illegible] 1976

3. REASON FOR REQUEST
[X] INITIAL REPORT [ ] CHANGE REPORT REQUIREMENTS [ ] REWRITE FORMAT

4. SERVICES REQUESTED IN DETAIL (Add enclosure if necessary)
For Pers-3C221.

BACKGROUND.

1. The Navy Resource Model (NARM) is presently being improved by integrating the QUIKPAY model. Data elements different from those previously used in the NARM are now required by OP-901 (via Pers-212). The elements described hereafter are required on an annual basis, embracing a 30 September to 30 September time frame. The first data are required no later than 1 December. Detailed criteria, together with preferred data source for obtaining the information, are as follows:

OVERALL CONCEPT.

2. 30 September enlisted inventory by length of service cell (LOS 0-1, 1-2, ------ 29-30, 30+) according to Pay Entry Base Date (PEBD), broken into the four categories specified in paragraph 3. Data source for the 30 September 1976 inventory, and that for subsequent years, should be the Enlisted Master Record (EMR).

3. CAT(1). FIRST-TERM THREE YEAR OBLIGORS, INCLUDING 3x6 RESERVES.

USN
a. SCIND = xFxxx, and
b. BR/CL = 11 or 15 or 23 or 25 or 68 or 90, and
c. TERM STAT = 1, and
d. TERM ENL = 3.

OR:

USNR
a. SCIND = xFxxx, and
b. BR/CL = 32 or 78 or 96, and
c. NO. ENL = 1, and
d. RADO MONS = 36.

ORIGINAL

5. TYPE FORMAT DESIRED (Attach Sample)

6. NO. COPIES DESIRED
One

7. DESIRED COMPLETION DATE
1 November 1976

8. FREQUENCY OF REPORT
Annual - 1 October

9. SECURITY CLASSIFICATION OF REPORT
Unclassified

10. DISPOSITION OF SOURCE DATA
Retain

11. JUSTIFICATION OF REPORT (Purpose and Authority)
See paragraph 1 above.

12. SHALL REPORT BE CANCELLED IN EVENT OF MOBILIZATION? [ ] YES [ ] NO

13. NAME OF PERSON ORIGINATING REQUEST
LT A.R. HOOPER (PERS-21212)

14. PHONE NO
X43416

15. SIGNATURE OF DIVISION OR BRANCH HEAD
CAPTAIN J. C. GAUTHIER, USN

DATA SOURCE: 30 September EMR. See Note 1 following CAT(3) for details of abatement action in respect of deserters.

CAT(2). FIRST-TERM FOUR, FIVE AND SIX-YEAR OBLIGORS.

a. SCIND = xFxxx, and
b. BR/CL = 11 or 15 or 23 or 25 or 68 or 90, and
c. TERM STAT = 1, and
d. TERM ENL > 3.

DATA SOURCE: 30 September EMR. See Note 1 following CAT(3) for details of abatement action in respect of deserters.

CAT(3). NON FIRST-TERM ENLISTED PERSONNEL, INCLUDING PRIOR SERVICE ENLISTEES, BUT EXCLUDING RETURNED DESERTERS.

USN
a. SCIND = xFxxx, and
b. BR/CL = 11 or 15 or 23 or 25 or 68 or 90, and
c. TERM STAT > 1.

OR:

USNR
a. SCIND = xFxxx, and
b. BR/CL = 32 or 78 or 96, and
c. TERM STAT = Z, and
d. NO ENL > 1.

DATA SOURCE: 30 September EMR.

NOTE 1. Inventories for categories (1), (2) and (3) are to be abated in each case by the number of returned deserters processed during the inventory year (1 October thru 30 September). Additionally, an inventory by PEBD of returned deserters is required; specification as follows:

CAT(4). RETURNED DESERTERS.

a. Navy Change Code = 191 or 193

DATA SOURCE: AMON tapes for 12 month period ending 30 September. (Initial report - 1 Oct 75 to 30 Sep 76.)

The CAT(1) abatement #'s will be computed from CAT(1) criteria b, c and d plus NCC = 191 or 193. Similarly, CAT(2) abatement will be criteria b, c and d with same NCC. CAT(3) abatement is criteria b, c (USN) or b, c, d (USNR) with same NCC.

4. FISCAL YEAR TOTAL GAINS.

Fiscal year total gains into categories (1), (2) and (3) listed in paragraph 3 above are required by length of service cell (PEBD) as of 30 September. Specifications are as follows:

CAT(1). FIRST TERM 3YOS, INCLUDING RESERVES.

a. BR/CL = 11 or 15 or 23 or 25 or 68 or 90, and
b. TERM STAT = 1, and
c. TERM ENL = 3, and
d. Navy Gain Code = 101 or 103 or 110 or 111.

OR:

a. BR/CL = 32 or 78 or 96, and
b. NO. ENL = 1, and
c. RADO MONS = 36, and
d. Navy Gain Code = 195.

DATA SOURCE: AMON tapes covering the period 1 October to 30 September. (Initial report - 1 Oct 75 to 30 Sep 76.)

CAT(2). FIRST TERM 4, 5 AND 6 YOS.

a. BR/CL = 11 or 15 or 23 or 25 or 68 or 90, and
b. TERM STAT = 1, and
c. TERM ENL > 3, and
d. Navy Gain Code = 101 or 103 or 110 or 111.

DATA SOURCE: AMON tapes covering the period 1 October to 30 September. (Initial report - 1 Oct 75 to 30 Sep 76.)

CAT(3). NON FIRST TERM ENLISTED PERSONNEL.

a. BR/CL = 11 or 15 or 23 or 25 or 68 or 90, and
b. TERM STAT > 1, and
c. Navy Gain Code = 110 or 111 or 150 or 151.

OR:

a. BR/CL = 32 or 78 or 96, and
b. TERM STAT = Z, and
c. NO. ENL > 1, and
d. Navy Gain Code = 195.

DATA SOURCE: AMON tapes covering the period 1 October to 30 September. (Initial report - 1 Oct 75 to 30 Sep 76.)

5. LOSS RATES FOR THE PERIOD 30 SEPTEMBER TO 30 SEPTEMBER BY LENGTH OF SERVICE ACCORDING TO PEBD FOR EACH OF CATEGORIES (1), (2) AND (3).

LOSS RATE DEFINITION: Rates must be in fractional form. Each rate will represent the fraction of the inventory which is lost (by attrition and at EAOS) during the year.

In order to compute the required loss rates beginning and end inventories are required. Normally, the end inventory will be the LOS matrix produced from the process in paragraphs 2 and 3 above abated by the fiscal year gains computed by the process in paragraph 4. The begin inventory is the matrix from the previous year.

NOTE: It is understood that no EMR for 30 September 1975 is now available. This being so, it is requested that, for the initial report, LOSS RATES be computed on the basis of 30 June 1975 → 30 June 1976 Enlisted Master Records.

Appendix B
DATA EXTRACT FORMAT

N.A.R.M. ENLISTED INVENTORY INPUT

CARD NUMBER 1

CARD COLUMN	DESCRIPTION	CODES
1	CARD #	'1'
2	TYPE INVENTORY	1=End FY 77 INVENTORY 2=FY 77 Returned Deserters 3=FY 77 Gains 4=FY 77 Losses 5=End FY 76 INVENTORY
3	CATEGORY CODE	1=1st Term 3YO,3X6 2=1st Term 4,5 & 6YO 3=NON 1st Term
4	SEX CODE	1=Male 2=Female
5	EDUC. CODE	1=< 12 Years 2=> 11 Years
6-10	LOS INVENTORY	Years of Service
11-15		0-14
16-20		
.		
.		
.		
.		
75-80		

CARD NUMBER 2

CARD COLUMN	DESCRIPTION	CODES
1	CARD #	'2'
2-5	SAME AS CARD # 1	
6-10	LOS INVENTORY	Years of Service
11-15		15-29
16-20		
.		
.		
.		
.		
75-80		

CARD NUMBER 3

CARD COLUMN	DESCRIPTION	CODES
1	CARD #	'3'
2-5	SAME AS CARD # 1	
6-10	LOS INVENTORY	Years of Service
11-15	LOS INVENTORY	30-31