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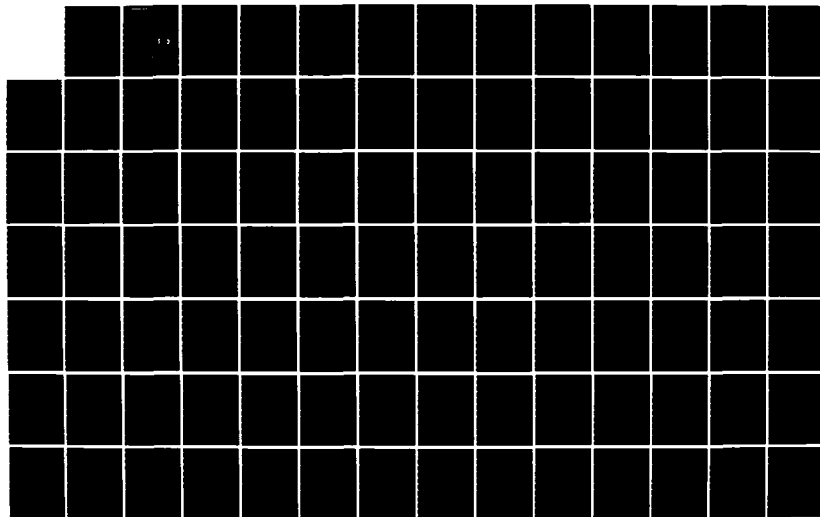
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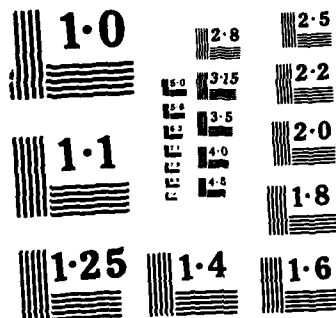
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July 1983



THE BILLET COST MODEL SYSTEM

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AD-A163 281

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1.0 INTRODUCTION

The Billet Cost Model System consists of three models which estimate the marginal economic cost of establishing and operating a billet in the U.S. Navy. Three types of labor are covered by the three models: enlisted, officer and civil service. Within each of these models, a billet is defined as the intersection of a paygrade and occupational group. The latter is at the level of rating for enlisted personnel, designator community for officers and functional occupational group (FOG) for civil servants.

The Enlisted Billet Cost Model has been produced in one form or another for about fifteen years. In the last four years the system was expanded to include, first, a civil service model and then an officer model. A reserve billet cost model was produced but has never been updated and is not included here.

This report describes a completely revised system of models from those that have appeared earlier. The cost elements have been restructured, the cost equations redefined and the reporting formats altered significantly from earlier versions. Hereafter, it is intended that the data sets will be updated each year, but the models remain as documented in this volume.

The changes in the mathematics of the models are an outgrowth of several years of research into manpower cost analysis. The first model to be changed was the Civilian Billet Cost Model. The differences in the outputs of that model compared to those of the military

model raised the possibility of putting all the models on a different footing. The major changes have been to shift the emphasis from average costs of manpower to marginal costs. This change has gone hand in glove with the perception that the most important user of these models is the acquisition community. There, resource allocation decisions are being made which can only be properly supported by marginal resource cost estimates. The alternatives, both average costs and budget costs, are important for other uses which are, however, less frequently required.

The new format of the output is also responsive to this altered view of the main users of the model. Far more information is provided than in the old format. Instead of annual billet cost and life cycle cost for four or five periods, the new models provide a detailed cost element breakdown and a table of present value multipliers that allow the user to construct his own discounted present value for a wide variety of time periods and discount rates.

Samples of the new tables for all three models are shown as Figures 1.1, 1.2 and 1.3.

The tables for enlisted men also include information on the breakdown of work hours between time spent working and unproductive time. A productive manhour rate is also published indicating the actual cost per hour of Navy enlisted labor. This value and the hours values make it possible, in combination with the published cost elements, to make detailed modifications to the billet cost for a particular billet type where more is known by the analyst than is implied by the use of averages.

ENLISTED BILLET COST MODEL

FY 1983 DATA

ALNAV
ALL NAVY

	GRADE						
	E-3	E-4	E-5	E-6	E-7	E-8	E-9
COST ELEMENTS							
1. Basic Pay	8867	10083	12015	15023	18321	21818	26403
2. S.R.B.	0	708	704	509	168	9	6
3. Proficiency	0	2	55	107	140	153	133
4. Hazard	50	97	231	262	362	468	463
5. Sea	1	437	585	739	928	772	630
6. V.H.A.	323	414	642	920	1137	1261	1412
7. Allowances	2364	2932	4011	5106	5694	6068	6485
8. Separation	338	684	601	281	419	781	1095
9. Retirement	286	387	625	1028	1251	1357	1400
10. Accession	1429	1320	1042	356	212	199	177
11. Initial Training	120	1683	1777	1101	618	227	50
12. Advanced Training	0	862	1080	1026	760	639	388
13. Undistributed Costs	1237	1441	1810	2229	2341	2370	2393
NAVY BILLET COST	15016	21049	25179	28687	32351	36121	41032
Unproductive Time Cost	3010	4220	5047	5751	6485	7241	8225
STANDARD MANYEAR COST	18026	25269	30226	34438	38836	43362	49258

*** ANALYSIS OF WORK HOURS BASED ON AVERAGE SEA/SHORE DUTY ***

Prod Manhour Rate	5.51	7.81	9.79	11.82	13.50	15.65	18.42
Productive Hours	2727	2695	2571	2428	2397	2308	2228
Unproductive Hrs	547	540	515	487	481	463	447
Navv Manyear Hrs	3274	3236	3087	2914	2877	2771	2674

Figure 1.1: Sample Output From The Enlisted Billet Cost Model

OFFICER BILLET COST MODEL

FY 1983 DATA

ALL NAVY

COST ELEMENTS	GRADE					
	0-1	0-2	0-3	0-4	0-5	0-6
1. Basic Pay	15375	20940	26175	31640	38251	48371
2. Continuation & Bonuses	6	34	1662	3818	1972	3671
3. Hazard	577	784	1293	1761	1678	854
4. Sea	70	124	193	346	396	177
5. V.H.A.	839	905	1205	1710	1843	1646
6. Allowances	4036	5058	5809	6590	7328	7935
7. Separation	594	567	889	724	1137	2950
8. Retirement	761	927	1157	1568	2043	2089
9. Accession	1830	1633	908	120	30	14
10. Initial Trainins	34603	16193	7677	974	198	151
11. Advanced Trainins	1303	1979	5090	10622	3034	1066
12. Undistributed Costs	2199	2418	2685	2950	3025	3065
NAVY BILLET COST	62193	51562	54743	62823	60935	71991
Unproductive Time Cost	12467	10336	10974	12593	12215	14431
STANDARD MANYEAR COST	74660	61898	65716	75416	73150	86422

Figure 1.2: Sample Output From The Officer Billet Cost Model

TABLE 1-100
ANNUAL BILLET COST BY ELEMENT FOR:
SCIENTISTS

GRADE	BASE PAY	FEGLI	RETIRMT	TRNG	PREM PAYS	UNDIST COST	RCRUIT	ANNUAL BILLET COST	DOWN TIME	STD MAN-YEAR COST	INITIAL BILLET COST
5	15214	33	85	669	650	1192	17	17860	2787	20647	398
7	18282	43	146	609	1111	1192	33	21415	4134	25549	490
9	22618	51	358	695	1571	1192	62	26545	5120	31666	656
11	29198	76	643	631	1694	1192	126	33558	6464	40023	1054
12	36366	89	890	875	962	1192	193	40565	7806	48371	1463
13	49425	113	1081	982	282	1192	224	53298	12055	65353	1641
14	63800	144	1340	1088	220	1192	254	68039	15396	83435	1810
15	63800	111	1337	1186	0	1192	286	67911	15360	83272	1969
16	63800	165	1252	581	0	1192	366	67441	15216	82657	2366

Figure 1.3: Sample Output From The Civilian Billet Cost Model

The work hour analysis is based on the proportions of time spent on sea and shore duty respectively. Since these vary, not only by rating, but also by pay grade within each rating, the productive manhour rate varies more than billet costs do. Among other things, these manhour rates should be looked at as an indication of how inexpensive military labor is when considered on an hourly basis. An alternative way of looking at the same information is that work hours are extremely long in the Navy compared to civilian firms. Since the latter represent competition for hiring the skills developed by the Navy, the low hourly cost might be seen as a poor trade-off with associated retention problems caused by related low hourly compensation.

All of the billet cost models are meant to produce comparable cost estimates, both among themselves, and with manyear costs generated by contractors. This is done, among other things, to satisfy OMB's requirements for testing the viability of contracting out certain government functions. For comparability, it is necessary to use the Standard Manyear Cost included in each table, rather than the billet cost. The standard manyear cost is based on a fictitious manyear consisting of 260 days of equivalent length.

No problem is posed by this requirement in the case of the Civilian Billet Cost Model since the basis for a civil service manyear is the same as the private sector standard (2080 hours). In the case of the military models, however, a problem arises due to the fact that sailors, particularly on sea duty, are obliged to work

considerably more than a normal full time work day. Lacking data on relative productivity, it is not really possible to correct for these differences accurately. In practice, the problem is generally avoided by the use of day accounting rather than hour accounting. The additional hours worked by military personnel are effectively ignored by comparing only the number of days on which they work. The alternative would be to collect reliable data on hours per day (for both military and civilian personnel) and make parallel estimates of productivity. Both of these tasks are too demanding to remain within the scope of the billet cost models.

The next three sections are complete discussions of the three billet cost models. Section 2 is the enlisted model, Section 3 the officer model and Section 4 the civilian model. Each of these sections begins with a general description of the model and then a detailed exposition of each of the cost elements. Section 5 is a description of updating procedures for the three models. The computer source code for all three models is published in a separate volume: "Billet Cost Model System: Program Source Code Listings." The output and a user's description and guide are also published as a separate annual volume: "Billet Costs of Enlisted, Officer and Civilian Naval Personnel."

2.0 THE ENLISTED BILLET COST MODEL

2.1 THE DEFINITION OF A NAVY ENLISTED BILLET

The best specification, for the enlisted Navy, is to define a billet in terms of its compensation (paygrade) level and NEC (Navy Enlisted Classification) required of personnel to fill it. Not only are most billets defined in this way but also specialized training, whose costs above all else distinguish between paygrade equivalent billets, is provided on an NEC basis.

However the inventories of the hundreds of NECs are in general too small to allow the application of the model's statistical estimation methods. Since NECs are grouped into ratings, which are large enough for the estimation techniques, we define a billet in terms of a rating and paygrade (pay rate, rate, grade are equivalent terms) specification. Even so, for certain survivor rates, we have had to achieve estimation confidence by further selective aggregation of some input data for close entities (see below).

2.1.1 The Concept of a Marginal Economic Billet

The aim of this project is to model the economic cost rather than the budgetary cost of a marginal billet. At the same time it is required that we include those costs that would arise as a consequence of a need for an additional billet, and exclude those that would not.

2.1.2 The Marginal Billet

The requirement of a marginal cost leads us to ignoring indirect or overhead costs and sunken or long-term costs. Overhead structures, such as command and administration, are assumed to remain stable for small changes in the service they must provide (as a consequence of small changes in force size). Such an assumption we feel is warranted by two observations: that small changes in demand tend to fluctuate; and that it is cost efficient, considering the replacement cost of overhead, not to do so.

However, when large force changes are being considered, overheads may become marginal to a specific Navy decision. Even for small changes, if the service demanded from the overhead structure goes beyond its capacity, large overhead costs may be incurred. Thus one should consider the appropriateness of including an imputed average or "expected" overhead cost when delivering a marginal cost.

Such a policy would lead to difficult problems. Firstly, no specific Navy decision may be anticipated (and its resultant cost included in this model). Secondly, this model may itself be playing a part in such a Navy decision. Consequently we have chosen to deliver no "expected" portion of any overhead cost, and to advise any person who is using this model--to make planning decisions that will have large or long-term impacts on Navy composition or size--to add on the cost of the resulting overhead changes himself. We believe that, where large overhead changes may occur, a large study will be made, and that, included in such a study will always be the

examination of which overhead systems will be affected, and to what extent.

The above argument also applies to long-term or sunken costs. They are not a marginal cost unless long-term capital investments are being considered, in which case their cost will be very much a part of the decision to make them or not.

Such a policy to deliver a marginal billet cost precludes current overhead costs and amortized portions of previously sunken investments from playing a role in the billet cost models.

2.1.3 The Economic Billet

Another element that differentiates our model from a budgetary billet cost is its delivery of the economic billet. In a budgetary estimate a billet cost accounts for the cost of a person who will, at work, fill the billet. The economic cost rather considers, in addition to the yearly cost of the person, the opportunity cost the person represents when he is not working for any reason. It is the cost to the Navy of having the person unproductive--the cost of the lost opportunity of the billet's marginal product.

For certain users of this model this is by no means an academic concept: for example, if designers assign four billets to a system under consideration, then they intend that four billets will have to be set aside and continuously filled in order to keep the system continuously operative. When a person is not on duty, someone else (who will also generate a cost) will have to fill in. In this sense, the extra cost of keeping the billet continuously filled is

the equivalent opportunity cost. NB: underlying this approach to costing downtime is the assumption that the value of a sailor's marginal productivity is equivalent to the real cost to the Navy of his employment.

On the same theme, although there are no direct retirement costs to the Navy, nevertheless economic obligations, in a stochastic sense, are being made for each further year in service. Therefore the present value of these obligations must be included in an estimate of the annual economic billet costs.

All costs incurred annually, but which are paid in the future (such as SRB payments made under the new scheme), must be discounted to their present economic value. Distribution of provisions "in-kind" (such as messing and government quarters) should also be costed to the economic billet; and in such a way as to reflect the opportunity cost associated with the Navy (or Government) not obtaining market values for these goods.

2.2 DATA PROCESSING PROBLEMS AND APPROACHES

At least 50% of the billet cost elements are directly paid on a bi-monthly basis to service members. Everyone--with a negligible exception--receives basic pay, but all the other pays are allocated only to specific members, as a recompense or a reward. Consequently the task arose of estimating a mean billet cost for each of the pays that were distributed only to eligible personnel.

The solution we obtained for the production of the Navy EBCM and OBCM was to use a tape provided by the Joint Uniform Military

Pay System (JUMPS) containing, for each service member, his rating (or designator), paygrade and LOS, and the individual pays he received over the course of a month.

The technique used in obtaining from these pays, mean cost contributions to the billet cost was to aggregate (during tape processing) both the total of whatever type of pay is under consideration and the count of persons receiving basic pay in the billet. The division of the total by the count provides a mean of this type of pay received per person in the billet type. By "type of pay" we mean the aggregation (again performed while initially processing the tape) of many pays: for example, over 20 hazardous duty pays are gathered as one. Thus over 120 pays were collapsed into less than 10, making the tape processing as efficient as possible.

It should also be noted that we used the number of persons receiving base pay as our estimate of persons in a billet rather than an inventory count from another source. This procedure was followed because inventory counts taken from different sources generally differ.

Three alternatives were available for general inventory data requirements: the JUMPS data base, the Enlisted Master Record (EMR) or the Department of Defense Individual (DODI) tapes from the Defense Manpower Data Center (DMDC). DMDC tapes are released three months after the end of every quarter and are practically an error free extract of the OMF. General experience has shown the EMR to float errors to the level of 20 to 30 percent in some variables.

Since we were already using JUMPS for inventory in costing out regular pays we decided to use the inventory throughout the model.

DMDC Loss/Edit records contained all the information the model needed for separation rates. In view of their high quality, we decided to use them for the BCMs. Their most important use was for deriving retirement distributions, severance losses and other losses from the force.

There was a problem in choosing a level of billet aggregation for obtaining decent continuation rates. A continuation rate may be defined preliminarily as the probability of a member's continuation in the same billet through the duration of a year in the service. Such continuation rates are influenced by several factors. These are discussed below in order of importance.

The member's LOS at the start of a year of service is by far the greatest influence on his continuation through the year. The rates also are influenced by the skill learned in a rating vis-a-vis its marketability in the private sector. The rates are probably also influenced a little by grade achieved but the correlation between LOS and grade is sufficiently close to make this factor unimportant. Incidentally, in the enlisted Navy, beyond the first enlistment, continuation rates are the gross appearance of underlying reenlistment, survival and migration phenomena.

We would have been satisfied to produce Rating/LOS specific continuation rates for the EBCM were it not for three important problems. These were small number problems in many LOS cells, mani-

pulation of apprentice and compressed ratings and the existence of lateral flows between both ratings and grades.

The first arose statistically in the small inventory sizes of many ratings. The only solution to this problem is to aggregate inventories at a higher level. For example, if we had chosen the four major rating groups (seaman, airman, constructionman and fireman), our method would have used inventories from two DMDC master tapes--for the current year and the previous year--and defined a rating/LOS continuation rate by:

$$CR(OF, LOS) = N_c(OF, LOS+1)/N_p(OF, LOS) ,$$

where

$N_c(OF, LOS+1)$ = the current DMDC inventory, and

$N_p(OF, LOS)$ = the DMDC inventory of one year prior.

This proved unnecessary, however, since we were able to save more rating specific detail by a different method of processing the data. This method is described below in the discussion of the third problem. This was an important saving since many costs (such as retirement and separation) are, in the main, determined by continuation rates.

The second problem arose in the existence of apprentice ratings and chief or parent ratings. This one was easily got around by using inventories from the Navy's FAST model which assigns apprentices statistically to the ratings into which they will eventually

be stationed, and which maintains members in the rating when, at paygrade E-9, they would have been transferred to a compressed parent rating. Thus if it were not for the third problem we would have managed to obtain rating specific continuation rates.

The third and final problem is that of lateral flow between ratings which we observed primarily in the early career years, fading out after roughly LOS 10. When lateral flow occurs, if one hasn't aggregated inventories (for the purposes of obtaining continuation rates only, of course) at a sufficiently high level to remove flow between one's divisions, one can obtain continuation rates greater than unity, reflecting a net flow during the year into a group. The task was to find appropriate aggregation levels for each of the LOS zones A (1-6), B (7-10), C (11-14) and D (15+) with the intention of obtaining progressively more specific continuation rates as LOS increased and lateral flows decreased.

Statistical analysis revealed that rating specific continuation rates could be obtained directly for LOS's beyond 10. Below LOS 10, continuation rates can be computed by aggregating ratings into groups corresponding to the six apprentice ratings: airmen, seamen, firemen, constructionmen, dentalmen and hospitalmen.

An alternative to the solution described above would have been to undertake a continuation rate decomposition by rating, (grade) and LOS, into lateral flow rates (promotion rates) and service gain and loss rates. While we believe the decomposition to be wholly desirable and eventually necessary for both the development of

sophisticated projection models--and even a moderately accurate model of training amortization--so difficult a task was beyond the scope of the contract.

Small numbers and problems due to compressed ratings (chiefs) arose again when collecting data for retirement from the DMDC DODI Loss/Edit file (DMDC Loss). The problem arose with severance, disability and death costs, data for which was collected at the rating level but was aggregated at the service wide level by grade and LOS.

The following sections provide an element-by-element description of the billet cost model. Each element's computation, data sources and theoretical problems are discussed in order. In some cases, these discussions are simple, base pay for example. In other cases, the discussion is quite lengthy and complex. Both retirement costs and training costs, for example, have absorbed disproportionate amounts of time and computational resources in these models.

2.3 BASE PAY

We have defined a billet as an rating/grade intersection. By "(i,j) billet" or " C_{ij} " we mean the class of persons with rating i and grade j or a variable specific to that class, respectively.

The Base Pay cost element includes both Base Pay and the Service's FICA contribution at the current tax rate.

$$(2.1) \quad C_{1ij} = BP_{ij} + \min[FCAP, BP_{ij} \cdot FRATE] ,$$

where

FRATE = the current FICA tax rate;

FCAP = the current maximum FICA payable; and

BP_{ij} = the mean base pay for the billet calculated from

$$BP_{ij} = T_{lij} / NP_{lij} ,$$

where

T_{lij} = the total base pay (extracted from the JUMPS pay records) received by (i,j) billet persons and

NP_{lij} = the number of (i,j) billet persons (receiving base pay).

2.4 SELECTIVE REENLISTMENT BONUSES

It was possible to adapt B/REFT, a model developed by The Assessment Group,* for the SRB BCM cost. It is currently being used to determine SRB levels by OP-136D, the Navy Enlisted SRB program manager, to project reenlistment rates, inventories and SRB levels over the next few years.

The data required for this element included estimates by rating, grade and LOS of the following items; all were available from the Navy's FAST model:

- Inventory counts.
- Reenlistment (and extensions for at least three years) by number of years reenlisted.
- SRB levels for the rating: Zones A, B and C.

* Neches, T. and D. Opstad, "Bonus Reenlistment Force Transition Model (B/REFT)," PR-A106.6, The Assessment Group, Santa Monica, 1982.

In the calculation of the SRB billet cost, the following computations are repeated and summed for each contractable period P, of possible reenlistment, from three to six years.

The rules stipulate that the bonus to be paid is equal to the product of the SRB level, base pay and the number of contracted years (P) up to a maximum of \$16,000. Presently the bonus is paid half now and the rest is distributed equally over the future P years. The amount distributed requires both discounting by the money discount rate (rather than the real rate) since bonus amounts will not be increased (as will other costs) to account for changes in the price level. We follow these costs into future grades as the reenlistee is promoted.

The amount paid immediately is:

$$(2.2) \quad A_{ijk}(P) = \{BP_{jk}Z_{ik}^P\}/2 ,$$

where

BP_{jk} = the total active federal service (TAFS) - adjusted base pay for grade j and LOS k;

Z_{ik} = the SRB level for rating_i and Zone in which is LOS k;
and

P = the period of reenlistment.

Define for each i,j,k the probability of being in each grade, G, for each of the following years L, $PG_{ijk}(G,L)$. To arrive at these probabilities we take the percentile range of the $N_{ij}(k)$ inventory in the distribution of rating i members with LOS k over the grades not less than j and use it as a ruler to find the corres-

ponding percentile range in the similar distribution of members with LOS L. A correction is then made so that the sum of the probabilities $PG_{ijk}(G,L)$ over the possible grades, G is equal to the probability of continuation to LOS L for a member with LOS k.

Then the present cost to each grade, G, of one reenlistment for P years in grade j and LOS k, incurred by the half of the bonus that is distributed, is:

$$(2.3) \quad B_{ijk}(P,G) = \sum_{t=k+1}^{k+P} [A_{ijk}(P)/P \cdot (1+i)^t] PG_{ijk}(G,t) ,$$

where

i = the money discount rate.

Let $R_{ijk}(P)$ denote the number of persons reenlisting qualified by i, j, k and P. They incur a cost in each grade of:

$$(2.4) \quad S_{ijk}(P,G) = R_{ijk}(P) \{A_{ijk}(P)d_j(G) + B_{ijk}(P,G)\} ,$$

where

$d_j(G) = 1$ if $j = G$, and $= 0$ otherwise (Kroenecker delta).

Consequently, the total cost per grade incurred by the $R_{ijk}(P)$ is $T_{ij}(P,G)$, the sum of the $S_{ijk}(P,G)$, for $k=1$ to 30. Let $U_i(P,G)$ be the sum of $T_{ij}(P,G)$ over cost incurring grades ($j=1$ to 9) and $V_i(G)$ be the sum of $U_i(P,G)$ over the various periods $P = 3$ to 9 of reenlistment or extension.

Finally we have arrived at $C_{2ij} = V_i(j)/N_{ij}$ where N_{ij} is the FAST (i,j) billet inventory count.

2.5 PROFICIENCY PAYS

Included under this title are the shortage specialty and special duty assignment propays receivable in the encouragement of continuation. They are directly accessible through the JUMPS pay records. We cost a mean per billet person:

$$(2.5) \quad C_{3ij} = T_{3ij}/NP_{1ij} ,$$

where

T_{3ij} = the total of all the above pays received; and

NP_{1ij} = the number of (i,j) billet persons receiving base pay.

2.6 HAZARD PAYS

Included under this title are duty area, hostile fire, diving, flight, submarine, parachute, demolition, pressure chamber and other pays for hazardous duty. They are directly accessible through the JUMPS pay records and we cost a mean per billet person:

$$(2.6) \quad C_{4ij} = T_{4ij}/NP_{1ij} ,$$

where

T_{4ij} = the total of all the above pays received; and

NP_{1ij} = the number of (i,j) billet persons (receiving base pay).

2.7 SEA PAYS

Included under this title are both career sea pay and the sea pay premium for lengthy sea duty. Both are directly accessible through the JUMPS pay records. We cost a mean per billet person:

$$(2.7) \quad C_{5ij} = T_{5ij}/NP_{1ij} ,$$

where

T_{5ij} = the total of all such pays received by billet personnel; and

NP_{1ij} = the number of billet personnel.

2.8 VARIABLE HOUSING ALLOWANCE

Isolated because of its size and location-specific (and thus rating-specific) variability. The mean allowance paid is statistically available through the JUMPS pay records:

$$(2.8) \quad C_{6ij} = T_{6ij}/NP_{1ij} ,$$

where

T_{6ij} = the total VHA paid to billet (i,j); and

NP_{1ij} = as usual the number of billet (i,j) persons receiving base pay.

2.9 OTHER ALLOWANCES

In this cost item appear the many pays and allowances that are either small or do not vary considerably from one rating to another. Foreign Duty Pay, Family Separation, Overseas Station and Clothing Maintenance Allowances are included items whose mean amounts paid per billet person are straightforwardly extracted from the JUMPS pay records. The contribution of the above items to this billet cost element is:

$$(2.9) \quad A = T_{7ij}/NP_{1ij} ,$$

where

T_{7ij} = the total of the above items paid out over a year; and

NP_{1ij} = the number of billet (i,j) personnel receiving base pay.

Basic Allowance for Subsistence, BAS, is accounted for by allotting to those not receiving a direct payment, a figure of \$3.88 which we have arrived at through an analysis of the MP-N annual budget report for subsistence in kind.

$$(2.10) \quad BAS = 365[\$3.88(NP_{1ij} - NP_{7ij}) + S_{7ij}]/NP_{1ij} ,$$

where

NP_{7ij} = the number of persons receiving directly some form of BAS;

S_{7ij} = the daily total of all BAS directly received; and

NP_{1ij} = the number of billet persons (receiving Base Pay).

Basic allowance for Quarters, BAQ is costed, together with BAQ-in-kind as follows. Four categories emerge from being either single or married (S or M) and receiving either government quarters or direct BAQ pay (G or B): let SG, SB, MG and MB respectively denote the number of persons (found from the frequency of corresponding types of BAQ codes in the JUMPS tape) in the above four categories. Also let SP and MP be the amount of BAQ pay directly received by single and married billet persons, respectively.

Then we derive a mean of BAQ and BAQ-in-kind as follows:

$$(2.11) \quad BAQ = \frac{(SG+SB)SP + (MG+MB)MP}{SG+SB+MG+MB} .$$

In "summing up," the billet manyear economic cost for allowances is:

$$(2.12) \quad C_{7ij} = A + BAS + BAQ .$$

2.10 RETIREMENT

The retirement cost element is actually the sum of four similar items of which retirement itself is by far the largest: the others are severance, disability and death. In the modeling of each of these there are two analytically separate steps.

Step one combines financial and actuarial methods in calculating, for those who will receive a time stream of payments, the cost incurred in each prior year of service. For example in this step of the retirement calculation--on behalf of a member of the service who will retire in grade GR and LOS LR--we compute the annual level payment required to fund all his retirement payments.

This general method represents a significant improvement over earlier methods. Among other things, earlier methods produced ill-behaved results, being very sensitive at the actual retirement age. Also, the use of level payments assumed to have begun at the date of service entry is a more pleasing notion, heuristically, than the one of stochastic accretion of the change in government obligations under the retirement provisions. In addition, the present formulation imparts a grade distribution to retirees in the form of a forecast unlike the older EBCM which assumed retirement in the observed grade.

While the first step computes and uses data that are service-wide, in the second step we take rating specific inventories, continuation rates and retirement distributions to produce a rating specific retirement cost. Thereby it is arranged that every service-wide calculation--that would otherwise have to be repeated for each rating--is preprocessed in the first step. Every calculation in the second step is unique; which is important since it is there that 105 rating-specific retirement costs are computed.

In the second step stochastic and statistical methods are used to estimate the following main parameters of retirement cost. The first is the relative proportion of persons who survive in the service to achieve vesting for retirement; and the second is the relative distribution (for those who became vested) of their final paygrades when they retire. The inner product of the vector of products of continuation rates to LOS twenty with the LOS inventory vector, provides us with the number of persons who eventually will retire. Such persons are distributed over final retirement grades to preserve an empirically derived retirement distribution. This is done according to the principle that the persons of a certain paygrade with lower LOS will go further, to retire in a higher grade.

The advantages of this "projection backwards" method--of using a future distribution to find present members' futures--over the "projection forwards" methods of taking promotion rates, expected times to promote and times in grade, amount to four:

1. Running time: Without a loss of accuracy, the computer model will run hundreds of times faster.

2. Accuracy in cost estimation: Since equal level payments are used, the grouping of LOS by final grade is all the "current" LOS precision required to assume the correct relative proportions of costs incurred by the relative distribution of retirements by grade. "Forward" methods cannot be controlled to achieve this future retirement distribution and proper weighting of costs.
3. Data collection: While retirement data are easily available (DMDC Loss) even to the level of some skill specificity, promotion data are very hard to come by, costly to process and require many times more storage.
4. In general, promotion data only provide a mean promotion pattern per paygrade and reveal no fast or slow differences. Thus the qualitative notion of persons of a certain grade with relatively LOS being on a faster promotion track than those with a higher LOS is lost. Our proposed method avoids the difficulty and preserves this notion in assigning lower LOS personnel to the higher grades of future retirement.

Both methods take a weighted cost average when taking into account the LOSs at retirement: there does not appear to be a way of predicting final LOS by current LOS or grade. We feel the only guidelines are the retirement patterns themselves. We found that the relative distributions of retirement by LOS for each grade were not rating specific and, hence, this step was preprocessed, further reducing computation time.

This method provides retirement costs that do not vary so much by rating as by grade. The reason is that the continuation rate--roughly 90% of the variance in which is explained by LOS--is the controlling variable in the computation. The result is rating specific, however, because the ratings themselves have different grade and LOS distributions. While the discount rate (fixed at 10% by the OMB) affects the amount of retirement costs it is the LOS

specificity of continuation rates that determines the relative costs between billet types.

2.10.1 Non-Disability Retirement

Step one: on retiring from the service with grade GR and LOS LR, our member will receive until his death, a monthly annuity:

$$(2.13) \quad A(\text{GR}, \text{LR}) = \min[2.5\% \text{LR}, 75\%] \text{BP}(\text{GR}, \text{LR}) ,$$

where $\text{BP}(\text{GR}, \text{LR})$ was his monthly base pay before retirement. Since base pay is awarded not according to TAFMS LOS (from which he receives vestment for retirement), but rather in accordance with TAFS LOS, which is always (statistically) a little larger than TAFMS, we take a data extract from the DMDC Loss Edit file of the average TAFS/TAFMS for each grade, rating compressed.

In addition to this annuity, his family will receive after the member's death) \$3,750 to help pay for costs incurred by his death, the occurrence of which we calculate as a function of his age at retirement (another DMDC Loss Edit file data extract) and his expectation of life from tables for enlisted servicemen (published by the DMDC Office of the Actuaries). Thus, the expected total number of monthly retirement payments the member receives is:

$$(2.14) \quad n1 = 12 \cdot \text{XL}[\text{Age}(\text{LR})] ,$$

where

$\text{Age}(\text{LR})$ = the service-wide mean age at LOS LR; and

$\text{XL}(\text{A})$ = the expectation of life at age A, in years.

The present value at retirement of all future retirement payments, $RTF(GR, LR)$, can be thought of as a sinking fund which would just pay the annuity and leave enough to pay the death gratuity and burial cost (\$3,750) when the member dies.

$$(2.15) \quad RTF(GR, LR) = A(1+i)^{-1} + A(1+i)^{-2} + \dots + A(1+i)^{-n1} + B(1+i)^{-n1}$$

$$= A \left[\frac{(1+i)^{n1} - 1}{i(1+i)^{n1}} \right] + B/(1+i)^{n1}$$

where

$$A = A(GR, LR);$$

$$B = \$3,750; \text{ and}$$

$$i = \text{the monthly real discount rate} = .833\% \text{ set by the OMB.}$$

We accumulate the value of this sinking fund during the member's service years. Distribution of this sum is accomplished by attributing to each year of active service a level payment, the accumulation and growth of which, over the years, is just sufficient to provide the fund necessary to pay retirement annuities and the death gratuity. The size of such a level payment can be calculated as:

$$(2.16) \quad RTP(GR, LR) = RTF(GR, LR) \left[\frac{1(1+i)^{n2}}{[(1+i)^{n2} - 1]} \right]_{12},$$

where

$$n2 = 12 \cdot LR.$$

In step two the LOS inventory cells 1 to 30 in each billet of grade G are grouped into retirement computation units (RCUs) G to 9 corresponding to the distribution of grades of retirement not less than G: call this retirement distribution PRG(GR), so that:

$$\sum_{GR=G}^9 PRG(GR) = 1 .$$

PRG(GR) for grade G is the probability for someone in grade G that will retire, of so doing from grade GR.

Leaving the means of the grouping until later, note that:

- 1) the number of persons from RCU(GR) who will retire will be:

$$(2.17) \quad NRCU(GR) = PRG(GR) \cdot contB ,$$

where

contB = the total number of those in this billet who will continue in the service until they are vested for retirement.

- 2) for each person in RCU(GR) that will retire a yearly cost (to the billet) should be assigned of size:

$$(2.18) \quad CRCU(GR) = \sum_{LR=a}^{30} RTP(GR, LR) PRL(GR, LR | GR) ,$$

where

RTP(GR, LR) is the level payment calculated in step one;

$PRL(GR, LR|GR)$ is the probability of retirement from $\{GR, LR\}$, given the event of retirement from grade GR , a service-wide data extract from the DMDC Loss Edit records. [This calculation is best preprocessed along with other step one calculations as the final calculation, the results of which, $CRCU(GR, LR)$ are provided in step two as a table-look-up entered via a data file.] And

$$a = \text{Max}[LRCU(GR), 20];$$

where

$LRCU(GR)$ is the average LOS for $RCU(GR)$.

3) the resulting billet cost

$$(2.19) \quad RTC_{ij} = \sum_{GR=G}^9 NRCU(GR)CRCU(GR)/N_{ij} ,$$

where

N_{ij} = the FAST inventory of this billet.

For a few $RCUs$, $LRCU(GR)$ will exceed 20, and must be explicitly calculated; in other cases no calculation need be performed since the resulting billet cost simplifies to:

$$(2.20) \quad RTC_{ij} = [\text{contB}/N_{ij}] \sum_{GR=G}^9 PRG(GR)CRCU(GR) ,$$

where $CRCU(GR)$ is just a table-look-up. Consequently, the algorithm runs, in practice, in a very short time, amounting to about 40 multiplications and 10 additions for each billet.

It remains now to demonstrate how (1) is achieved; i.e., how the number of persons from RCU(GR) who will retire, NRCU(GR), is set to PRG(GR)ContB. (See Equation 2.17.)

For each inventory cell of LOS L define as the number who will retire:

$$(2.21) \quad \text{cont}(L) = N_{ij}(L) \text{PCR}(L, 19) ,$$

where $N_{ij}(L)$ = the FAST LOS inventory; and $\text{PCR}(L, 19)$ = the product of continuation rates from LOS L to LOS 19 (is unity if L is greater than 19) and is exactly the probability of continuing in the service until vested for retirement. The total number in this billet that will retire is denoted by:

$$(2.22) \quad \text{contB} = \sum_{L=1}^{30} \text{cont}(L) .$$

Then let:

$$(2.23) \quad \text{Pcont}(L) = \text{cont}(L)/\text{contB}, \quad \text{for each } L = 1, \dots, 30.$$

To accomplish the grouping into RCUs, set initially a variable, LOS, to 31, two accumulators to zero, and initialize (to G) the final grade of retirement variable, GR. Then repeatedly accumulate the $\text{Pcont}(\text{LOS})$, decrementing LOS by 1 each time, until the accumulation exceeds PRG(GR): simultaneous with the accumulation of $\text{Pcont}(\text{LOS})$ is the accumulation of $\text{Pcont}(\text{LOS}) \cdot \text{LOS}$. Then the accumulators are linearly adjusted by subtracting the fraction of excess accumulation

and the adjustments are passed on to the accumulators as their initialization for the next RCU grouping. We calculate:

$$(2.24) \quad \text{LRCU}(\text{GR}) = \frac{\text{the accumulation of } \{\text{Pcont}(\text{LOS}) \cdot \text{LOS}\}}{\text{PRG}(\text{GR})} .$$

For the initialization of the next round GR is set to GR-1, LOS is left unchanged and accumulations are initialized to the adjustment subtracted at the adjustment step of the previous round. This round of initialization, accumulation, adjustment and LRCU calculation is continued until LRCU(GR) is not more than 20 (which will happen usually at the first round for billets with grades less than 8). For the remaining RCUs of the billet it is unnecessary to calculate the LRCU since LRCU only occurs in billet cost calculation step (2) as $\max[20, \text{LRCU}(\text{GR})]$. (See Equation 2.18.) It can be seen that this method ensures that (1) is satisfied.

Note that since the accumulation is the core of the algorithm, the running time of the computer model is very fast, indeed taking between 3 and 5 seconds per rating.* Since there are many ratings, this is a very important advantage of modeling retirement this way.

2.10.2 Severance

Step One: severance pay is a one-time expenditure, paid as a lump sum upon severance for disability. The size of the sum SVP is set to a multiple of monthly base pay being received prior to severance. The multiple is set to the number of six month periods (or

* This estimation of the algorithm's running time is based on using an IMS-8000 8 bit 4 MegaHertz micro-computer.

part thereof) served in active military duty, up to a maximum of twenty-four.

Since we gather inventory data by LOS and not by month or any division of a year, we have to estimate the average sum paid to a severing member. For a member with LOS L and grade G we do so by:

$$(2.25) \quad SVP(L) = \min\{24, [2 \cdot L + (2 \cdot L - 1)]/2\} \cdot BP(G, L) \\ = \min(24, 2 \cdot L - 0.5) \cdot BP(G, L)$$

where BP(G,L) is a TAFS-adjusted base pay as defined in the preceding section on retirement.

We have decided that the small loss of accuracy is outweighed by the extra expense in processing data tapes to the level of six month periods; this is in part justified by the fact of severance cost being only a very small part of the total billet cost, dwarfed into negligibility by even the relative size of retirement costs.

Step Two: experience has shown that in order to avoid estimation problems arising with small numbers, we cannot do better than to compress, in the first runs of the model, by rating the severance data collected from the DMDC Loss Edit tape into a service-wide table by grade and LOS of the probabilities of severance, PSV(G,L), during the current LOS. In which case, we estimate the severance cost to a billet by grade G as:

$$(2.26) \quad SVC_{ij} = \sum_{L=1}^{30} N_{ij}(L) PSV(G, L) SVP(G, L) / N_{ij} ,$$

where N_{ij} is the FAST billet inventory total, and $N_{ij}(L)$ is the FAST (i,j) billet inventory by LOS.

2.10.3 Disability Retirement

The first step is carried out along similar lines to non-disability retirement in calculating level payments required to fund the disability payments which could arise at a given point. The level payments are costed to each year prior to and inclusive of the year in which the disability occurs.

If a member retires disabled from grade G and LOS L with percentage disability D, then the monthly annuity he is entitled to is:

$$(2.27) \quad A(G,L,D) = \min[\max(D, 25\%L), 75\%]BP(G,L) ,$$

where $BP(G,L)$ is the final base pay received and is estimated via a TAFS adjustment.

Since a member's percentage disability is not reported along with notice of his retirement in the DMDC Loss edit tapes, we need to estimate the average annuity $A(G,L)$ awarded. To do so we calculate:

1. the $DAV(L)$ proportion of those in LOS L who are disabled and whose percentage disability exceeds 2.5% of their LOS; and
2. $PDAV(L)$, for the same population proportion, their average percentage disability.

These are derived from tables published by the DMDC Office of the Actuaries reporting each year the occurrence of disability and classified by grade, LOS and percentage disability.

Then the average annuity may be estimated by:

$$(2.28) \quad A(G,L) = \text{DAV}(L)A1[G,L,\text{PDAV}(L)] + [1-\text{DAV}(L)]A1(G,L,2.5\%L) .$$

Following the relevant reasoning in the retirement section, the cost for a disability retirement to each of the prior years:

$$(2.29) \quad \text{DSP}(G,L) = A(G,L) \left[\frac{(1+i)^{n1}-1}{i(1+i)^{n1}} \right] + B/(1+i)^{n1} \left[\frac{1(1+i)^{n2}}{[(1+i)^{n2}-1]} \right] 12 ,$$

where

$B = \$3,750$, the sum of death gratuity and burial costs,
 $i = 10\%$, the real discount rate,
 $n1 = 12 \text{ XL}[\text{age}(L)]$ (see Equation 3.14)
 $n2 = 12 L$

In step two the probability of becoming disabled in rating M with grade G and LOS L , $\text{PDS}(M,G,L)$, is estimated with precisely the same methods that are used for severance, and the same remarks directed to growing a data base apply here. Each year the number of persons expected to retire disabled from billet (i,j) , with LOS L , is $\text{PDS}(i,j,L)N_{ij}(L)$. For each such person a mean level payment of $\text{DSP}(j,L)/N_{ij}$ is included in the billet cost. Thus we derive the billet cost contribution due to disability retirement as:

$$(2.30) \quad \text{DSC}_{ij} = \sum_L \sum_{t \geq L} \text{DSP}(G,t) \cdot N \cdot \text{PDS}(M,G,t) / \sum_L N_{ij} ,$$

where

$N = N(M,G,t)$ is the FAST inventory count.

2.10.4 Death Benefits

Step one is again very similar. When a member dies, if he is married (or has dependents), his spouse receives \$3,750 as a death gratuity and cost of burial--or he receives a military burial whence \$750 is costed for burial-in-kind. In addition the government is responsible for providing a Dependents Indemnity Compensation, DIC as a monthly annuity, whose size depends on the final grade of the deceased member.

Thus the amount to be costed to each year of service prior to and inclusive of the married member's death is:

$$(2.31) \quad DTP1(G,L) = DIC(G) \left[\frac{(1+i)^{n1}-1}{i(1+i)^{n1}} \right] + B \left[\frac{i(1+i)^{n2}}{[(1+i)^{n2}-1]} \right] 12 ,$$

where

$$B = \$3,750$$

$$i = .10$$

$$n1 = 12 \cdot XL[Age(L)]$$

where Age is the age of the spouse when our member has LOS(L) (estimated from the median difference in age of husband and wife available in statistical abstracts of the US) and XL(a), her expectation of life at age a

$$n2 = 12 \cdot L$$

For members dying with no dependents, a burial-in-kind cost is attributable:

$$(2.32) \quad DTP2(G,L) = \$750 .$$

Thus we derive an average DTP weighted by $M(L)$, the proportion of service members who have dependents:

$$(2.33) \quad DTP(G,L) = DTP1(G,L)M(L) + DTP2(G,L)[1-M(L)] .$$

In step two the probability of dying in rating M with grade G and LOS L , $PDT(M,G,L)$ is estimated in precisely the same fashion as was PSV and PDS in the sections dealing with severance and disability. Whence the billet cost contribution due to death is:

$$(2.34) \quad DTC = \sum_L \sum_{t \geq L} DTP(G,t) \cdot N \cdot PDT(M,G,L) / \sum_L N ,$$

where, as usual, $N=N(M,G,L)$ is the FAST inventory count.

2.10.5 Total Cost in the Retirement Account

Total costs of retirement are made up of the sum of its elements, defined above. In summary, the economic cost of this element is:

$$(2.35) \quad C_{8ij} = RTC_{ij} + SVC_{ij} + DSC_{ij} + DTC_{ij} .$$

2.11 SEPARATION COSTS

There are two items in the manpower budget for separation costs: separation-PCS and separation pay. In addition, each separator qualifies for unemployment benefits for which a budget figure for ex-servicemen for each month of the preceding year is published in the Monthly Labor Review.

We award the distribution of the sum of these budgets, SEPBUDG among those who projectedly will separate in the current year.

The number of persons who will separate this year with length of service (L) from billet (i,j) is:

$$(2.36) \quad SN_{ij}(L) = N_{ij}(L)[1 - CR_i(L)] ,$$

where $N_{ij}(L)$ is the FAST (i,j) billet LOS L inventory count and $CR_i(L)$ is the i rating continuation rate from LOS cell L.

Denote the total number of service separators by SN. Then the separation cost awarded to the (i,j) billet is:

$$(2.37) \quad C_{9ij} = (SEP BUDG / SN) SN_{ij} / N_{ij} ,$$

where

$$N_{ij} = \sum_{L=1}^{30} N_{ij}(L) .$$

2.12 ACCESSION COSTS

In chronological order Recruitment, Enlistment Bonuses, Accession-PCS and Accession Clothing are the four budget items entered under this cost. In addition, we must include real accession training costs.* Let ACCSUM be the sum of all the above costs.

We amortize this sum over all service years. For each rating we locate the number of manyears bought and the distribution of these manyears by grade and LOS. In addition we total the number of manyears bought across rating, grade and LOS, service-wide. Call this total ACCMYS. Then the cost of each manyear obtained is:

* See Section 2.13 for the general conversion of training budget cost data to marginal cost estimates.

$$(2.38) \quad A = \text{ACCSUM}/\text{ACCMYS} .$$

For each rating, the number of manyears in LOS one is

$$(2.39) \quad \text{MY}(1) = \sum_j N_{ij}(1) ,$$

where $N_{ij}(L)$ = the number of persons in billet (i,j) with LOS L .

Correspondingly the number of manyears bought in each year L , subsequent to the first, is:

$$(2.40) \quad \text{MY}(L) = \text{MY}(1)\text{PCR}(1,L-1) ,$$

where $\text{PCR}(s,t-1)$ is the product of rating specific continuation rates from LOS s to $t-1$ and is just the probability of continuation from LOS s to LOS t .

For each LOS L , $\text{MY}(L)$ is distributed over grades parallel to the present distribution of inventory by grade, delivering $\text{MY}_j(L)$, the amount of $\text{MY}(L)$ distributed to billet (i,j) . Taking the sum:

$$(2.41) \quad \text{MY}_j = \sum_L \text{MY}_j(L) ,$$

provides us with the total accession cost attributed to this billet.

(The total of MY_j across j and ratings is ACCMYS defined above.)

The accession billet cost is calculated as:

$$(2.42) \quad C_{10ij} = \text{MY}_j A / N_{ij} ,$$

where, as usual, N_{jk} is the FAST billet inventory count.

2.13 INITIAL TRAINING

2.13.1 Data Sources

Any approach to modeling billet training costs has to gather two distinct sets of data: current training course costs, and student attendance. As regards the former there is only one source, the data provided by the RMS (Resource Management System) and data thence derived. With regard to the latter one may go to the EMR or to NITRAS (the Navy Integrated Training Resource Administration System).

RMS gathers and organizes resource expenditure costs as a centralized reporting system. Most Navy activities report to RMS, each activity containing an RMS office. The cost data is organized under many classifications among which are: "Operation and Maintenance" or "Manpower and Personnel," and the activity or sub-activity incurring the cost. At CNET (Chief of Naval Education and Training, Pensacola, Florida) the RMS analysis branch further organizes this data so as provide data for analysing course costs of training. They also add in student compensation costs, fill in data where it is lacking, and with course attendance data supplied by NITRAS, make attrition adjustments and distribute high level costs down, prorata, to the attended courses. The outcome is the PCCTT (Per Capita Cost To Train) data base containing course costs per course graduate.

For an attendance record, both the NITRAS SMF (Student Master File) and the EMR were insufficient for "A" School analysis: the EMR because there are only five training fields which are not enough fields to capture all the preparatory schooling that some NECs

require; and the SMF because it records, not historical training from the viewpoint of the present force, but records training to whom, where and when it happens. Consequently SMF student records contain the student's skill classification when he was trained, not the rating he received as a result of his training.

MIISA (Management Information and Instructional Systems Activity) in Pensacola, Florida, manage the NITRAS data bases and provide training reports to the EMR. They also provide file merges between the SMF and the EMR, bring data fields over from the EMR, expanding the usefulness of the SMF. MIISA has provided the EBCM with a tape that overcomes the insufficiencies mentioned above by matching, for "A" schooling, FY81 records of attendance with current rating information from the EMR.

2.13.2 Model

Generally speaking one may divide up costs to train into two categories. In the first place there are student (training billet) costs, which should include not only all pays and allowances but also pays-in-kind and increases in expected future obligations (e.g., retirement). And then there are training course costs. These include the cost of such elements as instructor billet costs, supplies and administrative support. The latter shall be referred to as course training costs and the former as student training costs. Over all types of Navy supplied training it is estimated that the student training cost element is the greater.*

* See: Warner, J. and J. Waterman, "Modeling The Costs of Specialized Training", CRC 337, Center for Naval Analyses, Alexandria, 1977.

The student training cost is a direct product of the time he spends training away from a productive billet, and his "billet cost" while he is training. The time spent away from "productive" duty may in many instances be significantly longer than the duration of the training course itself. Factors contributing to this extra duration include the wait for a class to become open and the respective wait for an active duty billet to be assigned subsequent to his training.* We may take into account this extra time cost since relevant data is available (fields from the NITRAS SMF contain information both as to the duration of the course and the time spent "on board" the training activity).

On the other hand PCC To Train costs are costs per graduate. They may, however, be converted back to costs per student week of attendance since PCCTT records of course costs contain information on the attrition rate for the course and the average course length per graduate.

Thus the first stage in our model is to return the course cost per graduate to a course cost per student week and then accumulate, for all records of course attendance on the SMF, the total training cost (for any specification of personnel--we use rating and LOS). The total training cost is the accumulation of the sum, for each record, of the course cost--as the product of the course time and the course cost per student week--and the student training cost--

* We must thank Mr. D. Niedert at MIISA for recommending this to our attention.

from the product of the "on board" time and a training billet cost per week.

The student training billet cost is the Navy Billet Cost (the eventual outcome of the whole model) without present or future training costs, and with a different "downtime cost" adjustment. Also, Sea Pay is excluded on the basis that no course training is done at sea. Training costs, then, of all the billet cost elements, must be calculated last.

The downtime adjustment depends on how one is to view the training in terms of the extra costs it incurs to the Navy. We suggest that the Navy views "A" schooling as a preparatory activity prior to productive billet duty: then no billet downtime cost need be added to account for the training time since that time is not spent away from an active duty station. Instead the student training cost is seen as an investment whose benefits are reaped equally over all future service--(amortization: see below).

While there is no downtime adjustment to be made to this cost, we must make an adjustment for accrued leave--and for short courses, holidays. No adjustment is made for time lost for transients, prisoners or patients (TPP) since in such an occurrence to a student he is setback and must retake (or continue from the same point in) a later course. Consequently we pick up this cost factor properly by including in our cost accumulations every record of course attendance, whether the course was passed or failed. For more details turn to the technical section.

"C" schooling may be viewed in an altogether different manner. Time spent at "C" school is time spent away from an otherwise productive billet. This leads us to observe that a student (compensation) training cost, per se, has automatically already been included in the model: annual costs have been calculated--which are quite indifferent as to whether the year was spent at the billet duty station, or on leave, or at school. However a downtime cost is incurred--as an opportunity cost for the billet being inactive while the sailor is being trained. This leads to a conceptual problem.

While a sailor is on leave both he and his billet are unproductive. But during his training, though his billet is "down", from the point of the Navy the sailor is actively engaging himself in useful work, work to which the Navy has assigned him. Indeed "training billets" are assigned for all noninitial training. We have taken the view, therefore, that it is conceptually more appropriate to model "C" schooling, like "A" schooling, as an investment for future benefits: and to be amortized likewise.

Summarizing: while on "C" school training, a sailor has been assigned to another (a training) billet; a student (compensation) training cost, along with a course cost are thereby generated; this cost is viewed as a human capital investment whose benefits are to be reaped in future active duty billets; and is therefore amortized over all future years of active service.

2.13.3 Marginal Costs

The Billet Cost Models are intended to model as best they can the real cost to the Navy of supporting an extra billet of whatever

specification. Following the policy of this model, as explained in Section 2.1, under the definition of a "marginal billet," we have tried to remove cost elements from the PCCTT data that are mainly prorated overhead costs. For example, host operation and support costs.

The PCCTT data base from which we derive "course costs per student week," is intended to model the complete costs of training-- which we believe it does, due to the efforts of Mr. W. Cocks and his associates of the RMS analysis branch at CNET.

Training costs maintained in this data base, on a per graduate basis, include not only the cost of instructors and other military and civilian labor, but also supplies and equipment, many student costs, and training equipment maintenance and depreciation. In addition these costs are supplemented with prorated overhead costs. For example, the functional command CNTECHTRA, the program development activity NETPDC, and the activity/facility and host support overheads are itemized as elements within each course record. For complete details of the PCCTT data base please contact the RMS analysis branch at CNET, Pensacola, Florida.

In addition to removing overhead costs where we can we have removed training equipment costs. The cost for the maintenance of training equipment is a separate item and included, but we have judged that, in the main, training equipment cost represents a sunk cost.

Costs of training equipment are actually depreciation. In general, estimation of training equipment cost depends on whether

the original cost of the item was less than or greater than \$3000. If the former, it is expensed and does not enter this element. If it cost more than \$3000, for the next ten years nine percent of its original cost is amortized in this element. Hence, it is a sunk cost and excluded from our estimate.*

Please note that there are no costs for ships and airplanes in the PCCTT data base since they represent no cost to the Navy. They are salvaged vehicles, either taken from active or inactive Naval use, or from another Armed Service's salvage.

As regards student costs as they appear in the PCCTT data base, they are removed and substituted is a student cost obtained directly in the model.

2.13.4 Amortization: Distribution of Costs Over Pay Grades

From recruitment onward, investments are made by the Navy embodied in its enlisted personnel. Through such immediate expenditures the Navy expects to derive certain benefits over each enlistee's subsequent years of service. An obvious example is the cost of training--the benefits from which may be reflected in a member's increased marginal productivity. A simpler example is accession clothing cost whose benefit extends over the useful life of the clothing. Ideally, the cost of a billet should reflect the current amortization of all capital investments made earlier. In this section we shall explain the amortization technique we have chosen.

* The policy of marginal costing for this model is reviewed in Sections 2.1 and 2.2.

Assume we have developed, for each rating, a vector of total yearly training costs by year of service. The procedure to derive these training cost totals by LOS is described above and detailed below in Section 2.13.6. These totals are then divided by corresponding inventories which must be LOWBALLED, as are those of FAST.

The resulting series can be thought of as a composite, unamortized training cost profile. To the extent that the data allow, this series represents an accurate portrayal of training costs, when they occur, through the career path of all individuals currently serving in a given rating.

Billets, however, are specified, not by year of service, but by rank and rating. As a consequence, we break down the composite series into subsets corresponding to the grades E-1 through E-9. To do so, however, requires that the raw series also be transformed by amortization of training costs. The method for doing so requires a rationale or a particular view of why enlisted Navy personnel are trained and what the anticipated outcome of the training process is.

Military personnel are trained so that they may be more productive in future operational billets. [This is in contradistinction to the reasons why civil servants are granted training which seems to serve as a reward and not to warrant amortization at all.]* As a consequence, the cost of those future billets should reflect the cost of earlier training. If, preparatory to a four-year tour of duty as a cost analyst, a member receives one year of training in

* See Section 4.7.

cost analysis, the cost of that training should be amortized over the four years he will spend as a cost analyst. If, in fact, this were the way the Navy employed personnel and if, in addition, no residual value were available from the training at the end of the tour, the limited amortization period would be appropriate. In fact, however, neither of those conditions hold for the bulk of training provided to Navy personnel.

The central fact is that the Navy, as an employer of men, makes rules for their development and utilization. This is done with a purely internal set of values (the Navy finds it valuable to have a man working in job A who has skill B). The Navy defines his productivity to be higher as a consequence of this extra skill which may, in some objective frame of reference, appear to be quite useless in carrying out the duties of A. But the Navy defines and measures both costs and benefits in this regard. Doing so is a perfectly legitimate procedure mirrored by many private firms (especially with their management personnel).

The rationale just presented begins to break down somewhat when billet costs are developed for comparison with alternative forms of labor. For example, if a billet currently occupied by a sailor is being compared to one for a civil servant expected to perform the same duties, implicit in the comparison is the difference in training background available to the two types of labor. To continue the example above, the civilian may have training specific to job A, but won't have the B skill. In making the cost comparison, then, we are

forced to make an independent judgment of the ancillary benefits associated with B training in the A post, and leaven our understanding of the pure cost comparison.

The pattern of training cost amortization we have selected is, therefore, equal distribution of the cost of any event forward to all subsequent duty years. This amounts to spreading the expected training cost of any year of service equally over all subsequent manyears of service. If a hundred men receive a certain training course when their LOS is t and if their continuation rates were, say 50% each year and zero at LOS 30 then the number of service manyears generated by this course would be 100 in the first year, 50 in the second, 25 in the next, and so on. In all, the total of service manyears generated would be around 200. In this hypothetical example our amortization scheme would allocate $100/200 = 1/2$ of the total cost of the course to the first year, $50/200 = 1/4$ of the cost to the second year, and to the next $25/200 = 1/8$ of the cost of the course, etc, thus assigning the whole cost down the future years. Note that this is identical to obtaining a per manyear cost ($\text{cost}/200$) and imputing it to every billet year observed after completion of the course: the algorithm does exactly this.

The last step of the process is to divide the stream into rank groups for valid ranks of the rating. This is done by taking a weighted average of all LOS costs with the personnel of each LOS found in the rank group. This procedure provides rank-related amortized training cost estimates for each rating.

2.13.5 Technical Details

Initial training consists of the "A" school pipelines: advanced training of "C" and "F" schooling. Both are discussed together as their costing is identical.

The PCCTT data are costs per course graduates. This means that the total yearly costs of running the course have been prorated among only those that successfully complete the course. The required for this model are costs per student week since student billet costs while training are based on a longer duration than the duration of the course.

The transformation of per graduate costs into student week costs may be made with other course data that accompany the cost data. Each course record on the PCCTT contains:

PCC\$	the per capita cost;
CLW	the course length in weeks;
ATTRW	student weeks of training lost by student attrition;
GRADS	the number of course graduates in the year.

The transformation is then just:

$$PSW\$ = PCC \cdot GRADS / (GRADS \cdot CLW + ATTRW) ,$$

that is, the per student week cost = the total annual cost ($PCC \cdot GRADS$) divided by the total annual student weeks taught ($GRADS \cdot CLW + ATTRW$).

The next step is to produce an LOS vector of total annual training costs, $TATC(L)$, $L=1, \dots, 30$, for each rating and type of training ("A," "C" or "F"). Since both types of training are

treated in the same manner (q.v., Section 2.13.2), in what follows all reference to a specific type of training will be dropped.

The method is to sum course and student costs for each incidence of student training recorded on a suitable year's SMF. For "A" school training this means taking a SMF from a couple of year's back so that student records may be extended to include the rating they were awarded as a result of the training. For records of persons who were not awarded a rating subsequent to their training, their training cost is allocated to a rating on the basis of a match of the record's course processing code (CDP) to a rating via a table obtained from a document called CNETNOTE 1514. This document is an outcome of research, undertaken by CNET N-36, into initial training pipelines for each rating.

TATC (L) is the accumulation, considering all records of training (from the SMF, whether passed or not) of personnel with a particular rating and LOS, of the following:

$$PSW\$ \cdot CRSW + TB\$ \cdot OBW$$

where

PSW\$	the per student week course cost obtained above;
CRSW	weeks of course attendance, adjusted for weekends and, for short courses, holidays also;
TB\$	the student's training billet cost which depends on his paygrade at the time of his training;
OBW	weeks spent "on board" the training activity.

CRSW and OBW are both obtained from the SMF record. A discussion on how TB\$ is obtained is to be found in Section 2.13.2.

With TATC (L) in hand, the next step is to amortize the costs over all future service years. A statistical (fictional) training cost per capita, PCTC (L) is produced:

$$PCTC(L) = TATC(L)/N(L) ,$$

where N(L) is a LOWBALLED inventory of the rating by LOS. Then, for each LOS, the expected further service life, EFSL(L) is calculated using current continuation rates, CR(L):

$$EFSL(L) = \sum_{t=L}^{30} \prod_{i=L}^t CR(i)$$

as the sum of the product of the continuation rates. This produces the same result as the usual formula since CR(30), the probability of serving beyond LOS 30, is by definition nil.

Our amortization scheme is to take the costs PCTC(L) in each L and distribute them down the following years of service. Define the amortized cost vector by:

$$(2.43) \quad ATC(L) = \sum_{t=1}^L PCTC(t)/EFSL(t)$$

where PCTC(t)/EFSL(t) are the correct (on average) costs to attribute to each future service year.

The final step is to distribute the LOS specific costs over the rating grades. For each each billet (i,j) incumbent we attribute a cost of ATC(L) so, summing we obtain:

$$(2.44) \quad A(j) = \sum_{L=1}^{30} ATC(L) \cdot N_{ij}(L) ,$$

as the total training costs to be assigned to billet (i,j). Thus we arrive at, say, the initial training contribution to the (i,j) billet cost:

$$(2.45) \quad C_{11ij} = A(j)/N_{ij} .$$

2.14 ADVANCED TRAINING

Includes costs for "C" and "F" schooling. The cost methodology is precisely the same as that for "A" schooling, described in Section 2.13.

2.15 UNDISTRIBUTABLE MARGINAL COSTS

Several budget items do not call for a specific method of distribution and naturally should be allocated on a per capita basis. The items are:

- PCS costs for Operational, Organizational and Rotational moves
- Commissary Costs
- Prisoner Apprehension Costs
- CHAMPUS claims and administration of claims.

All but the last are so distributed but since CHAMPUS costs are incurred by a service member's dependents we have to distri-

bute these only among those members with dependents. This subgroup of members with dependents is billet-isolatable in the same way we isolate them for the calculation of BAQ.* Note that PCS costs for training are absent from this list as they are included per capita on the PCCTT cost file.

2.16 THE NAVY BILLET COST

This is just the sum of the above costs:

$$(2.46) \quad C_{14jk} = C_{1jk} + C_{2jk} + \dots + C_{13jk} .$$

2.17 UNPRODUCTIVE TIME COSTS AND THE STANDARD MANYEAR COST

The above costs represent the actual cost per year of an enlisted serviceman. The cost of a billet, however, must also reflect the fact that an individual for one reason or another supplies more or less than the standard manyear of labor, around which the concept of a billet is built. Absences from work include holiday and leave, transience, prison and patient time (TPP) and also time spent in formal, informal and on-the-job training (which we treat separately from the rest). The annual amount of productive time is calculated in hours by:

$$(2.47) \quad HP = HB - LV ,$$

where

LV = hours spent on leave, holidays and TPP;

HB = the standard number of hours by which a billet is measured.

* c.f., 2.9 Allowances.

In general HB is assumed to be, and for most duty stations is 2080 hours implying an 8 hour day. However there is some reason for considering sea duty to demand more than a normal 8 hour day and 5 day week. In the model as it is presently constellated the provision has been made for two kinds of duty stations, shore and sea duty. Statistics for the distribution of each billet's incumbents among these duty stations is available from an Assessment Group summary of MAPMIS, called STATSUM. In our model calculations were made for each station and the results were weighted and averaged.

Our immediate aim is to calculate an hourly billet work rate:

$$(2.48) \quad W = C_{14}/HP ,$$

which will serve as our basis for cost comparisons.

To arrive at a Standard Manyear Cost we simply take the product of the number of hours a billet serves a year and the billet specific work hourly rate:

$$(2.49) \quad SMC = HB \cdot W ,$$

a cost to compare with the costs offered by civilian contractors if we bear in mind; one, that they estimate their costs on the basis of a standard manyear of 2080 hours; and two, civilians may only substitute for shore duty billets, whose manyear is also 2080 man-hours.

Reformulating Equation 2.47 and multiplying by W we get:

$$(2.50) \quad HB \cdot W = HP \cdot W + LV \cdot W ,$$

or

$$(2.51) \quad SMC = C_{14} + U ,$$

where U is the unproductive cost, due to leave, holidays and TPP.

3.0 THE OFFICER BILLET COST MODEL

3.1 THE CONCEPT OF A MARGINAL ECONOMIC BILLET

The aim of this project is to model the economic cost rather than the budgetary cost of a marginal billet. At the same time it is required that we include those costs that would arise as a consequence of a need for an additional billet, and exclude those that would not.

3.1.1 The Marginal Billet

The requirement of a marginal cost leads us to ignoring indirect or overhead costs and sunken or long-term costs. Overhead structures, such as command and administration, are assumed to remain stable for small changes in the service they must provide (as a consequence of small changes in force size). Such an assumption we feel is warranted by two observations: that small changes in demand tend to fluctuate; and that it is cost efficient, considering the replacement cost after dismantling a piece of overhead, not to do so.

However, when large force changes are being considered, overheads may become marginal to a specific Navy decision. Even for small changes, if the service demanded from the overhead structure goes beyond its capacity, (large) overhead costs will be incurred. Thus one should consider the policy of including an imputed average or "expected" overhead cost when delivering a marginal cost.

Such a policy would lead to difficult problems. Firstly, no specific Navy decision may be anticipated (and its resultant cost

included in this model). Secondly, this model may itself be playing a part in such a Navy decision. Consequently we have chosen to deliver no "expected" portion of an overhead cost, and to advise any person who is using this model--in order to make planning decisions that will have large or long-term impacts on Navy composition or size--to add on the cost of the resulting overhead changes himself. We believe that, where large overhead changes may occur, a large study will always be made, and that, included in such a study will always be the examination of which overhead systems will be affected, and to what extent.

The above argument also applies to long-term or sunken costs. They are not marginal unless long-term capital investments are being considered, in which case their cost will be very much a part of the decision to make them or not.

Such a policy to deliver a marginal billet cost precludes current overhead costs and amortized portions of previously sunken investments from playing a role in the billet cost models.

3.1.2 The Economic Billet

Another element that differentiates our model from a budgetary billet cost is its delivery of the economic billet. In a budgetary estimate a billet cost accounts for the cost of a person who will, at work, fill the billet. The economic cost rather considers, in addition to the yearly cost of the person, the opportunity cost the person represents when he is not working for any reason. It is the cost to the Navy of having the person unproductive--the cost of the lost opportunity of the billet's marginal product.

For certain users of this model this is by no means an academic concept: for example, if designers assign four billets to a system under consideration, then they intend that four billets will have to be set aside and continuously filled in order to keep the system continuously operative. When a person is not on duty, someone else (who will also generate a cost) will have to fill in. In this sense, the extra cost of keeping the billet continuously filled is the equivalent opportunity cost. Underlying this approach to costing downtime is the assumption that the value of a sailor's marginal productivity is equivalent to the real cost to the Navy of his employment.

On the same theme, although there are no direct retirement costs to the Navy, nevertheless economic obligations, in a stochastic sense, are being made for each further year in service. Therefore the present value of these obligations must be included in an estimate of the annual economic billet costs.

All costs incurred annually, but which are paid in the future (such as SRB payments made under the new scheme), must be discounted to their present economic value. Distribution of provisions "in-kind" should also be costed to the economic billet; and in such a way as to reflect the opportunity cost associated with the Navy (or Government) not obtaining market values for these goods.

3.1.3 Billet Cost Estimation

At least 50% of the billet cost elements are directly paid on a bi-monthly basis to service members. Everyone--with a negligible

exception--receives basic pay, but all the other pays are allocated only to specific members, as a recompense or a reward. Consequently the task arose of estimating a mean billet cost for each of the pays that were distributed only to specific personnel.

The solution we obtained for the production of the Navy OBCM was to use a tape provided by the Joint Uniform Military Pay System (JUMPS) containing, for each service member, his designator code, paygrade and LOS, and the individual pays he received over the course of a month.

The technique used in obtaining from these pays, mean cost contributions to the billet cost was to aggregate (during tape processing) both the total of whatever type of pay is under consideration and the count of persons receiving basic pay in the billet. The division of the total by the count provides a mean of this type of pay received per person in the billet type. By "type of pay" we mean the aggregation (again performed while initially processing the tape) of many pays: for example, over 20 specialty pays are gathered as one. Thus over 120 pays were collapsed into less than 10, making the tape processing as efficient as possible.

It should also be noted that we used the number of persons receiving base pay as our estimate of persons in a billet rather than an inventory count from another source. This procedure was followed because inventory counts taken from different sources generally differ.

Three alternatives were available for general inventory data requirements: the JUMPS data base, the Officer Master Record (OMR)

or the Department of Defense Individual (DODI) tapes from the Defense Manpower Data Center (DMDC). DMDC tapes are released three months after the end of every quarter and are practically an error free extract of the OMR. General experience has shown the OMR to float errors to the level of 20 to 30 percent in some variables. Since we were already using JUMPS for inventory in costing out regular pays we decided to use the inventory throughout the model.

DMDC Loss/Edit records contained all the information the model needed for separation rates. In view of their high quality, we decided to use them for the BCMs. Their most important use was for deriving retirement distributions, severance losses and other losses from the force.

There was a problem in choosing a level of billet aggregation for obtaining decent continuation rates. A continuation rate may be defined preliminarily as the probability of a member's continuation in the same billet through the duration of a year in the service. Such continuation rates are influenced by several factors. These are discussed below in order of importance.

The member's LOS at the start of year is by far the greatest influence on his continuation. The rates also are influenced by the skill acquired in a designator community vis-a-vis its marketability in the private sector. The rates are probably also influenced a little by grade achieved but the correlation between LOS and grade is sufficiently close to make this factor unimportant.

We would have been satisfied to produce community and LOS specific continuation rates for the OBCM were it not for a large

degree of lateral flow between the officer communities. In particular the unrestricted line officers may latterally transfer to the restricted line or staff corps after a non-specifiable length of service. Indeed the SDOs may receive mid-career officers from any unrestricted line community.

Consequently the usual method of obtaining continuation rates restricted us to using all Navy continuation rates throughout. An alternative was available, which was judged to be too complicated for the billet cost models, of constructing continuation rates on an individual basis.

The usual method, followed here, is to find a level of aggregation that is closed to lateral transfer and simply to divide the count of persons currently of a certain LOS by the count of persons in the previous LOS last year.

The alternative is to process the two consecutive inventories on an individual basis. There is no restriction on the level of aggregation you may use. For all officers classified to belong to a certain unit of analysis in one year, process the next year's inventory file to see if they are still in the force. This procedure would provide the kind of continuation rate needed for the BCMs. It would not matter if an officer had transferred himself to another unit (designator community) as we would not wish to count this as a loss. In this case a continuation rate for a certain designator/LOS is the proportion of those in that classification last year, who are this year still in the force.

The following sections provide an element-by-element description of the Officer Billet Cost Model. Each element's computation, data sources and theoretical problems is discussed in order. In some cases, these discussions are simple, base pay for example. In other cases, the discussion is quite lengthy and complex. Both retirement costs and training costs, for example, have absorbed disproportionate amounts of time and computational resources in these models. Many of the cost elements are defined in a manner which is either similar or identical to their counterparts in the Enlisted Billet Cost Model. The descriptions have been repeated here for the convenience of the user, making it unnecessary to have reference to another part of the document every time a common element is encountered.

3.2 BASE PAY

We have defined a billet as an rating/grade intersection. By "(i,j) billet" or " C_{ij} " we mean the class of persons with rating i and grade j or a variable specific to that class, respectively.

The Base Pay cost element includes both Base Pay and the Service's FICA contribution at the current tax rate.

$$(3.1) \quad C_{lij} = BP_{ij} + \min[FCAP, BP_{ij} \cdot FRATE] ,$$

where

FRATE = the current FICA tax rate;

FCAP = the current maximum FICA payable; and

BP_{ij} = the mean base pay for the billet calculated from

$$BP_{ij} = T_{1ij}/NP_{1ij} ,$$

where

T_{1ij} = the total base pay (extracted from the JUMPS pay records) received by (i,j) billet persons and

NP_{1ij} = the number of (i,j) billet persons (receiving base pay).

3.3 CONTINUATION AND BONUSES

Monthly continuation pays and annual bonuses paid to shortage specialties were combined in this element. Included were officers' special and incentive pays for critical specialists; dental, veterinary, aviators, doctors, etc. All, with one exception, the nuclear annual bonus, were estimated from the JUMPS data as per usual:

$$(3.2) \quad CB_{ij} = T_{2ij}/NP_{1ij} ,$$

where

T_{2ij} = the total continuation pay and bonuses (extracted from the JUMPS pay records) received by (i,j) billet persons; and

NP_{1ij} = the number of (i,j) billet persons (receiving base pay).

The nuclear annual bonus, however, is paid on 30th September each year and the JUMPS tape, to reflect FY83 pay scales, must be for a FY83 month (we choose October to be able to update the model as early as possible in the year). Thus we have to model the distribution of the nuclear annual bonus, by which we mean: to model the distribution of persons to whom the bonus is distributed.

Persons receive this bonus if they are nuclear qualified and are not receiving one of the two other incentive nuclear pays. The Planning and Resources Management Department at the Navy Finance Center were able to supply us with the total amounts paid in nuclear annual bonuses in FY82, the totals specified by paygrade. Our procedure entailed distributing each of these paygrade totals across the officer communities. (These totals were not inflated as there is no increase in the bonus award this year.)

The distribution of nuclear qualified personnel, by paygrade and community, was obtained as a summary from the DMDC Officer Master File. Two indications of nuclear qualification were looked for and if either one were present on an individual's record then a nuclear qualified officer was counted according to his paygrade and community.

The first indication was the NOBC (Navy Officer Billet Classification) field. The NOBC describes the type of billet to which the officer is currently assigned. Its code, four characters, may be translated with a Manual Of Navy Officer Classifications (NAVPERS 15839C). Nuclear qualified billets are coded as 9371 to 9374 and 9392 to 9394. The second is the AQD (Additional Qualification) three character code which indicates nuclear qualified if one of the following: SC2 to SC6, SNO to SN3 or KD1 to KD5.

The nuclear annual bonus total distributed to each billet was calculated by the equation:

$$(3.3) \quad TNB_{ij} = TN_j \cdot NQ_{ij} / NQ ,$$

where

TN_j = the total nuclear annual bonus amount paid to officers of paygrade j ;

NQ_{ij} = the number of (i,j) billet persons who are nuclear qualified; and

NQ = the total number of nuclear qualified personnel.

Thus the nuclear annual billet cost to each billet is just:

$$(3.4) \quad NB_{ij} = TN_{ij} / NP_{1ij} ,$$

where, as usual

NP_{1ij} = the number of (i,j) billet persons (receiving base pay).

The total in this cost account is thus:

$$(3.5) \quad C_{2ij} = CB_{ij} + NB_{ij} .$$

3.4 HAZARD PAYS

Included under this title are duty area, hostile fire, diving, flight non-crew, submarine, parachute, demolition, pressure chamber and other pays for hazardous duty. They are directly accessible through the JUMPS pay records and we cost a mean per billet person:

$$(3.6) \quad C_{4ij} = T_{4ij} / NP_{1ij} ,$$

where

T_{4ij} = the total of all the above pays received; and

NP_{1ij} = the number of (i,j) billet persons (receiving base pay).

3.5 SEA PAY

Included under this title are both career sea pay and the sea pay premium for lengthy sea duty. Both are directly accessible through the JUMPS pay records. We cost a mean per billet person:

$$(3.7) \quad C_{5ij} = T_{5ij}/NP_{1ij} ,$$

where

T_{5ij} = the total of all such pays received by billet personnel; and

NP_{1ij} = the number of billet personnel.

3.6 VARIABLE HOUSING ALLOWANCE

Isolated because of its size and location-specific (and thus rating-specific) variability. The mean allowance paid is statistically available through the JUMPS pay records:

$$(3.8) \quad C_{6ij} = T_{6ij}/NP_{1ij} ,$$

where

T_{6ij} = the total VHA paid to billet (i,j); and

NP_{1ij} = as usual the number of billet (i,j) persons receiving base pay.

3.7 OTHER ALLOWANCES

In this cost item appear the many pays and allowances that are either small or do not vary considerably from one rating to another. BAS (Basic Allowance for Subsistence), Foreign Duty Pay, Family Sep-

aration, Overseas Station and Clothing Maintenance Allowances are included items whose mean amounts paid per billet person are straightforwardly extracted from the JUMPS pay records. The contribution of the above items to this billet cost element is:

$$(3.9) \quad A = T_{7ij} / NP_{1ij} ,$$

where

T_{7ij} = the total of the above items paid out over a year; and

NP_{1ij} = the number of billet (i,j) personnel receiving base pay.

Basic allowance for Quarters, BAQ is costed, together with BAQ-in-kind as follows. Four categories emerge from being either single or married (S or M) and receiving either government quarters or direct BAQ pay (G or B): let SG, SB, MG and MB respectively denote the number of persons (found from the frequency of corresponding types of BAQ codes in the JUMPS tape) in the above four categories. Also let SP and MP be the amount of BAQ pay directly received by single and married billet persons, respectively.

Then we derive a mean of BAQ and BAQ-in-kind as follows:

$$(3.10) \quad BAQ = \frac{(SG+SB)SP + (MG+MB)MP}{SG+SB+MG+MB} .$$

In "summing up," the billet manyear economic cost for allowances is:

$$(3.11) \quad C_{7ij} = A + BAQ .$$

3.8 RETIREMENT

The retirement cost element is actually the sum of four similar items of which retirement itself is by far the largest: the others are severance, disability and death. In the modeling of each of these there are two analytically separate steps.

Step one combines financial and actuarial methods in calculating, for those who will receive a time stream of payments, the cost incurred in each prior year of service. For example in this step of the retirement calculation--on behalf of a member of the service who will retire in grade GR and LOS LR--we compute the annual level payment required to fund all his retirement payments.

This general method represents a significant improvement over earlier methods. Among other things, earlier methods produced ill-behaved results, being very sensitive at the actual retirement age. Also, the use of level payments assumed to have begun at the date of service entry is a more pleasing notion, heuristically, than the one of stochastic accretion of the change in government obligations under the retirement provisions. In addition, the present formulation imparts a grade distribution to retirees in the form of a forecast.

While the first step computes and uses data that are service-wide, in the second step we take rating specific inventories, continuation rates and retirement distributions to produce a rating specific retirement cost. Thereby it is arranged that every service-wide calculation--that would otherwise have to be repeated for

each rating--is preprocessed in the first step. Every calculation in the second step is unique; which is important since it is there that 21 officer community-specific retirement costs are computed.

In the second step stochastic and statistical methods are used to estimate the following main parameters of retirement cost. The first is the relative proportion of persons who survive in the service to achieve vesting for retirement; and the second is the relative distribution (for those who became vested) of their final paygrades when they retire. The inner product of the vector of products of continuation rates to LOS twenty with the LOS inventory vector, provides us with the number of persons who eventually will retire. Such persons are distributed over final retirement grades to preserve an empirically derived retirement distribution. This is done according to the principle that the persons of a certain paygrade with lower LOS will go further, to retire in a higher grade.

The advantages of this "projection backwards" method--of using a future distribution to find present members' futures--over the "projection forwards" methods of taking promotion rates, expected times to promote and times in grade, amount to four:

1. Running time: Without a loss of accuracy, the computer model will run hundreds of times faster.
2. Accuracy in cost estimation: Since equal level payments are used, the grouping of LOS by final grade is all the "current" LOS precision required to assume the correct relative proportions of costs incurred by the relative distribution of retirements by grade. "Forward" methods cannot be controlled to achieve this future retirement distribution and proper weighting of costs.

3. Data collection: While retirement data are easily available (DMDC Loss) even to the level of some skill specificity, promotion data are very hard to come by, costly to process and require many times more storage.
4. In general, promotion data only provide a mean promotion pattern per paygrade and reveal no fast or slow differences. Thus the qualitative notion of persons of a certain grade with relatively LOS being on a faster promotion track than those with a higher LOS is lost. Our proposed method avoids the difficulty and preserves this notion in assigning lower LOS personnel to the higher grades of future retirement.

Both methods take a weighted cost average when taking into account the LOSs at retirement: there does not appear to be a way of predicting final LOS by current LOS or grade. We feel the only guidelines are the retirement patterns themselves. We found that the relative distributions of retirement by LOS for each grade were not designator specific and, hence, this step was preprocessed, further reducing computation time.

3.8.1 Non-Disability Retirement

Step one: On retiring from the service with grade GR and LOS LR, our member will receive until his death, a monthly annuity:

$$(3.12) \quad A(\text{GR}, \text{LR}) = \min[2.5\% \text{LR}, 75\%] \text{BP}(\text{GR}, \text{LR}) ,$$

where BP(GR,LR) was his monthly base pay before retirement. Since base pay is awarded not according to TAFMS LOS (from which he receives vestment for retirement), but rather in accordance with TAFS LOS, which is always (statistically) a little larger than TAFMS, we take a data extract from the DMDC Loss Edit file of the average TAFS/TAFMS for each grade, rating compressed.

In addition to this annuity, his family will receive after the member's death) \$3,750 to help pay for costs incurred by his death, the occurrence of which we calculate as a function of his age at retirement (another DMDC Loss Edit file data extract) and his expectation of life from tables for enlisted servicemen (published by the DMDC Office of the Actuaries). Thus, the expected total number of monthly retirement payments the member receives is:

$$(3.13) \quad n1 = 12 \cdot XL[Age(LR)] ,$$

where

Age(LR) = the service-wide mean age at LOS LR; and

XL(A) = the expectation of life at age A, in years.

The present value at retirement of all future retirement payments, RTF(GR,LR), can be thought of as a sinking fund which would just pay the annuity and leave enough to pay the death gratuity and burial cost (\$3,750) when the member dies.

$$(3.14) \quad RTF(GR,LR) = A(1+i)^{-1} + A(1+i)^{-2} + \dots + A(1+i)^{-n1} + B(1+i)^{-n1}$$

$$= A \left[\frac{(1+i)^{n1} - 1}{i(1+i)^{n1}} \right] + B/(1+i)^{n1}$$

where

A = A(GR,LR);

B = \$3,750; and

i = the monthly real discount rate = .833% set by the OMB.

We distribute the cost of this sinking fund or "present value" over our member's service years. Distribution of this sum (just a simple equal division of this sum over each year of service if the discount rate were zero) is accomplished by costing to each year of active service a level payment, the accumulation and growth of which, over the years, is just sufficient to provide the sinking stream fund necessary to pay retirement annuities and the death gratuity. The size of such a level payment can be calculated as:

$$(3.15) \quad RTP(GR, LR) = RTF(GR, LR) \left[\frac{1}{[(1+i)^{n2} - 1]} \right] 12 ,$$

where

$$n2 = 12 \cdot LR.$$

In step two the LOS inventory cells 1 to 30 in each billet of grade G are grouped into retirement computation units (RCUs) G to 6 corresponding to the distribution of grades of retirement not less than G: call this retirement distribution PRG(GR), so that:

$$(3.16) \quad \sum_{GR=G}^6 PRG(GR) = 1 .$$

PRG(GR) for grade G is the probability for someone in grade G that will retire, of so doing from grade GR.

Leaving the means of the grouping until later, note that:

- 1) the number of persons from RCU(GR) who will retire will be:

$$(3.17) \quad \text{NRCU}(\text{GR}) = \text{PRG}(\text{GR}) \cdot \text{contB} ,$$

where

contB = the total number of those in this billet who will continue in the service until they are vested for retirement.

- 2) for each person in RCU(GR) that will retire a yearly cost (to the billet) should be assigned of size:

$$(3.18) \quad \text{CRCU}(\text{GR}) = \sum_{\text{LR}=\text{a}}^{30} \text{RTP}(\text{GR}, \text{LR}) \text{PRL}(\text{GR}, \text{LR} | \text{GR}) ,$$

where

RTP(GR,LR) is the level payment calculated in step one;

PRL(GR,LR|GR) is the probability of retirement from {GR,LR}, given the event of retirement from grade GR, a service-wide data extract from the DMDC Loss Edit records. [This calculation is best preprocessed along with other step one calculations as the final calculation, the results of which, CRCU(GR,LR) are provided in step two as a table-look-up entered via a data file.] And

$$\text{a} = \text{Max}[\text{LRCU}(\text{GR}), 20];$$

where

LRCU(GR) is the average LOS for RCU(GR).

- 3) the resulting billet cost

$$(3.19) \quad \text{RTC}_{1j} = \sum_{\text{GR}=\text{G}}^6 \text{NRCU}(\text{GR}) \text{CRCU}(\text{GR}) / \text{N}_{1j} ,$$

where

N_{ij} = the DMDC inventory of this billet.

For a few RCUs, $LRCU(GR)$ will exceed 20, and must be explicitly calculated; in other cases no calculation need be performed since the resulting billet cost simplifies to:

$$(3.20) \quad RTC_{ij} = [contB/N_{ij}] \sum_{GR=G}^6 PRG(GR)CRCU(GR),$$

where $CRCU(GR)$ is just a table-look-up. Consequently, the algorithm runs, in practice, in a very short time, amounting to about 40 multiplications and 10 additions for each billet.

It remains now to demonstrate how (1) is achieved; i.e., how the number of persons from $RCU(GR)$ who will retire, $NRCU(GR)$, is set to $PRG(GR)ContB$. (See Equation 3.17.)

For each inventory cell of LOS L define as the number who will retire:

$$(3.21) \quad cont(L) = N_{ij}(L)PCR(L,19),$$

where $N_{ij}(L)$ = the DMDC LOS inventory; and $PCR(L,19)$ = the product of continuation rates from LOS L to LOS 19 (is unity if L is greater than 19) and is exactly the probability of continuing in the service until vested for retirement. The total number in this billet that will retire is denoted by:

$$(3.22) \quad \text{contB} = \sum_{L=1}^{30} \text{cont}(L) .$$

Then let:

$$(3.23) \quad \text{Pcont}(L) = \text{cont}(L)/\text{contB}, \quad \text{for each } L = 1, \dots, 30.$$

To accomplish the grouping into RCUs, set initially a variable, LOS, to 31, two accumulators to zero, and initialize (to G) the final grade of retirement variable, GR. Then repeatedly accumulate the Pcont(LOS), decrementing LOS by 1 each time, until the accumulation exceeds PRG(GR): simultaneous with the accumulation of Pcont(LOS) is the accumulation of Pcont(LOS)•LOS. Then the accumulators are linearly adjusted by subtracting the fraction of excess accumulation and the adjustments are passed on to the accumulators as their initialization for the next RCU grouping. We calculate:

$$(3.24) \quad \text{LRCU}(\text{GR}) = \frac{\text{the accumulation of } \{\text{Pcont}(\text{LOS}) \cdot \text{LOS}\}}{\text{PRG}(\text{GR})} .$$

For the initialization of the next round GR is set to GR-1, LOS is left unchanged and accumulations are initialized to the adjustment subtracted at the adjustment step of the previous round. This round of initialization, accumulation, adjustment and LRCU calculation is continued until LRCU(GR) is not more than 20 (which will happen usually at the first round for billets with grades less than 5). For the remaining RCUs of the billet it is unnecessary to calculate the LRCU since LRCU only occurs in billet cost calculation

step (2) as $\max[20, \text{LRCU}(\text{GR})]$. (See Equation 3.18.) It can be seen that this method ensures that (1) is satisfied.

Note that since the accumulation is the core of the algorithm, the running time of the computer model is very fast, indeed taking between 3 and 5 seconds per community for the Navy OBCM.* Since there are many communities, this is a very important advantage of this model.

3.8.2 Disability Retirement

The first step is carried out along similar lines to non-disability retirement, calculating level payments required to fund the disability payments which could arise at a given point. The level payments are costed to each year prior to and inclusive of the year in which the disability occurs.

If a member retires disabled from grade G and LOS L with percentage disability D, then the monthly annuity he is entitled to is:

$$(3.25) \quad A(G, L, D) = \min[\max(D, 25\%L), 75\%]BP(G, L),$$

where $BP(G, L)$ was the final base pay received and is estimated via a TAFS adjustment.

Since a member's percentage disability is not reported along with notice of his retirement in the DMDC Loss edit tapes, we need to estimate the average annuity $A(G, L)$ awarded. To do so we calculate:

* This estimation of the algorithm's running time is based on using an IMS-8000 8 bit 4 MegaHertz micro-computer.

1. the DAV(L) proportion of those in LOS L who are disabled and whose percentage disability exceeds 2.5% of their LOS; and
2. PDAV(L), for the same population proportion, their average percentage disability.

These are derived from tables published by the DMDC Office of the Actuaries reporting each year the occurrence of disability and classified by grade, LOS and percentage disability.

Then the average annuity may be estimated by:

$$(3.26) \quad A(G,L) = \text{DAV}(L)A_1[G,L,\text{PDAV}(L)] + [1-\text{DAV}(L)]A_1[G,L,2.5\%L] .$$

Following the relevant reasoning in the retirement section, the cost for a disability retirement to each of the prior years:

$$(3.27) \quad \text{DSP}(G,L) = A(G,L) \left[\frac{(1+i)^{n_1}-1}{i(1+i)^{n_1}} \right] + B/(1+i)^{n_1} \left[\frac{1(1+i)^{n_2}}{[(1+i)^{n_2}-1]} \right]^{12} ,$$

where

B = \$3,750, the sum of death gratuity and burial costs,
 i = 10%, the real discount rate,
 n₁ = 12 XL[Age(LR)] (see Equation 3.13)
 n₂ = 12 L

In step two the probability of becoming disabled in community M with grade G and LOS L, PDS(M,G,L), is estimated from a data extract of the DMDC Officer EDIT/LOSS file. Small numbers constrain us to use probabilities aggregated over the force and by paygrade, leaving LOS as the only axis of variability. Each year the number of persons expected to retire disabled from billet (i,j), with LOS L, is

$PDS(i,j,L)N_{1j}(L)$. For each such person a mean level payment of $DSP(j,L)/N_{1j}$ is included in the billet cost. Thus we derive the billet cost contribution due to disability retirement as:

$$(3.28) \quad DSC_{1j} = \sum_L \sum_{t \geq L} DSP(G,t) \cdot N_{1j} \cdot PDS(M,G,t) / \sum_L N_{1j} ,$$

where

$N=N(M,G,t)$ is the DMDC inventory count.

3.8.3 Death Benefits

Step one is again very similar. When a member dies, if he is married (or has dependents), his spouse receives \$3,750 as a death gratuity and cost of burial--or he receives a military burial whence \$750 is costed for burial-in-kind. In addition the government is responsible for providing a Dependents Indemnity Compensation, DIC as a monthly annuity, whose size depends on the final grade of the deceased member.

Thus the amount to be costed to each year of service prior to and inclusive of the married member's death is:

$$(3.29) \quad DTP1(G,L) = DIC(G) \left[\frac{(1+i)^{n1}-1}{1(1+i)^{n1}} \right] + B \left[\frac{1(1+i)^{n2}}{[(1+i)^{n2}-1]} \right] 12 ,$$

where

$B = \$3,750$

$i = 10\%$

$n1 = 12 \cdot XL[Age(L)]$

where Age is the age of the spouse when our member has LOS(L) (estimated from the median difference in age of husband and wife available in statistical abstracts of the US) and XL(a), her expectation of life at age a

$$n_2 = 12 \cdot L$$

For members dying with no dependents, a burial-in-kind cost is attributable:

$$(3.30) \quad DTP_2(G, L) = \$750 .$$

Thus we derive an average DTP weighted by M(L), the proportion of service members who have dependents:

$$(3.31) \quad DTP(G, L) = DTP_1(G, L)M(L) + DTP_2(G, L)[1-M(L)] .$$

In step two the probability of dying in community M with grade G and LOS L, PDT(M, G, L) is estimated in precisely the same fashion as was PDS in the section dealing with disability. Whence the billet cost contribution due to death is:

$$(3.32) \quad DTC = \sum_L \sum_{t \geq L} DTP(G, t) \cdot N \cdot PDT(M, G, L) / \sum_L N ,$$

where, as usual, $N = N(M, G, L)$ is the DMDC inventory count.

3.8.4 Total Cost in the Retirement Account

Total costs of retirement are made up of the sum of its elements, defined above. In summary, the economic cost of this element is:

$$(3.33) \quad C_{7ij} = RTC_{ij} + DSC_{ij} + DTC_{ij} .$$

3.9 SEPARATION COSTS

There are two items in the manpower budget for separation costs: separation-PCS and separation pay. In addition, each separator qualifies for unemployment benefits for which a budget figure for ex-servicemen for each month of the preceding year is published in the Monthly Labor Review.

We award the distribution of the sum of these budgets, SEPBUGD among those who projectedly will separate in the current year.

The number of persons who will separate this year with length of service (L) from billet (i,j) is:

$$(3.34) \quad SN_{ij}(L) = N_{ij}(L)[1 - CR_i(L)] ,$$

where $N_{ij}(L)$ is the DMDC (i,j) billet LOS L inventory count and $CR_i(L)$ is the i rating continuation rate from LOS cell L.

Denote the total number of service separators by SN. Then the separation cost awarded to the (i,j) billet is:

$$(3.35) \quad C_{8ij} = (SEPBUGD/SN)SN_{ij}/N_{ij} ,$$

where

$$N_{ij} = \sum_{L=1}^{30} N_{ij}(L) .$$

3.10 ACCESSION COSTS

In chronological order Recruitment, Accession-PCS and Accession Clothing are the three budget items entered under this cost. Let ACCSUM be the sum of all the above costs.

We amortize this sum over all service years. For each community we locate the number of manyears bought and the distribution of these manyears by grade and LOS. In addition we total the number of manyears bought across grade and LOS, service-wide. Call this total ACCMYS. Then the cost of each manyear obtained is:

$$(3.36) \quad A = \text{ACCSUM} / \text{ACCMYS} .$$

For each community the number of manyears in LOS one is:

$$(3.37) \quad \text{MY}(1) = \sum_j N_{ij}(1) ,$$

where $N_{ij}(L)$ = the number of persons in billet (i,j) with LOS L .

Correspondingly the number of manyears bought in each year L , subsequent to the first, is:

$$(3.38) \quad \text{MY}(L) = \text{MY}(1) \text{PCR}(1, L-1) ,$$

where $\text{PCR}(s, t-1)$ is the product of continuation rates from LOS s to $t-1$ and is just the probability of continuation from LOS s to LOS t .

For each LOS L , $\text{MY}(L)$ is distributed over grades parallel to the present distribution of inventory by grade, delivering $\text{MY}_j(L)$, the amount of $\text{MY}(L)$ distributed to billet (i,j) . Taking the sum:

$$(3.39) \quad \text{MY}_j = \sum_L \text{MY}_j(L) ,$$

provides us with the total accession cost attributed to this billet. (The total of MY_j across j is ACCMYS defined above.) The accession billet cost is calculated as:

$$(3.40) \quad C_{9ij} = MY_{jA}/N_{ij} ,$$

where, as usual, N_{jk} is the DMDC billet inventory count.

3.11 INITIAL TRAINING

Training for officers is nowhere completely recorded. NITRAS collects some training data, the officer master record (OMR) some, but nowhere is there a complete record of officer training. Indeed, it is not possible to combine available sources to create a satisfactory record.

An initial effort was made to update an officer training cost study completed in 1980 by BK Dynamics. The study,* the cost of which exceeded the annual BCM system maintenance cost, gathered by officer community direct costs of training. It was soon found that our preliminary updating efforts were not going to yield the requisite data in the time allotted for this contract.

Instead we inflated the 1980 costs to 1983 dollars. As they did not include student costs, these were added in, using the studies' estimates for length of each type of training and the sum of the officer billet cost elements excluding sea and hazard pays. The results were then amortized in the same fashion as are enlisted training costs. Please see Sections 2.13.4 and 2.13.5 for more detail.

Initial training was separated out from advanced training. Initial training was any training required for an officer's first

* "Officer Billet Cost Model, Phase II--Final Report," TR-3-442, BK Dynamics, Rockville, 1980.

tour of duty: the cost of any subsequent training was entered under the advanced training account.

3.12 ADVANCED TRAINING

Incudes costs for any training subsequent to an officer's first tour of duty. See Section 3.11.

3.13 UNDISTRIBUTABLE MARGINAL COSTS

Several budget items do not call for a specific method of distribution and naturally should be allocated on a per capita basis. The items are:

- PCS costs for Operational, Organizational and Rotational moves
- Commissary Costs
- Prisoner Apprehension Costs
- CHAMPUS claims and administration of claims.

All but the last are so distributed but since CHAMPUS costs are incurred by a service member's dependents we have to distribute these only among those members with dependents. This subgroup of members with dependents is billet-isolatable in the same way we isolate them for the calculation of BAQ.*

3.14 THE NAVY BILLET COST

This is just the sum of the above costs:

$$(3.41) \quad C_{13jk} = C_{1jk} + C_{2jk} + \dots + C_{12jk} .$$

* c.f., 3.7 Allowances.

3.15 UNPRODUCTIVE TIME COSTS AND THE STANDARD MANYEAR COST

The above costs represent the actual cost per year of an officer. The cost of a billet, however, must also reflect the fact that an individual for one reason or another supplies more or less than the standard manyear of labor, around which the concept of a billet is built. Absences from work include holiday and leave, transience, prison and patient time (TPP) and also time spent in formal, informal and on-the-job training (which we treat separately from the rest). The annual amount of productive time is calculated in hours by:

$$(3.42) \quad HP = HB - LV ,$$

where

LV = hours spent on leave, holidays and TPP;

HB = the standard number of hours by which a billet is measured.

In general HB is assumed to be, and for most duty stations is 2080 hours implying an 8 hour day. However there is some reason for considering sea duty to demand more than a normal 8 hour day and 5 day week. In the model as it is presently constellated the provision has been made for two kinds of duty stations, shore and sea duty. Statistics for the distribution of each billet's incumbents among these duty stations have not however become available at this time.

Our immediate aim is to calculate an hourly billet work rate:

4.0 THE CIVILIAN BILLET COST MODEL

4.1 INTRODUCTION

The Civilian Billet Cost Model (CBCM) is a computer-driven model of all costs associated with creation and staffing of a civil service billet in the Navy. The model system includes two major elements: a data file and a program. The data file contains records for each of the variables used in final computations of billet costs. That is, the data have been processed to a great extent before being entered in the file. The program reads the files, combines the data appropriately and develops two estimates: initial costs and annually recurring costs. Thereafter, these values are combined with discount factors to produce first year, undiscounted single year, and multi-year estimates of billet cost by grade and occupational category.

The CBCM is intended to be used for two general types of problems. The model can be used to:

- estimate the marginal cost of a new or existing civil service billet specified by grade and broad occupational category;
- estimate total costs of civil service employees either Navy-wide or for major subgroups.

The first general category of uses refers mainly to problems involving the substitutability of various types of resources--i.e., the substitution of civil service for other types of labor or the substitution of capital for labor. A primary objective of the CBCM is

to enable the Navy to compare the cost of civilian billets with military or contract personnel in order to evaluate the cost-effectiveness of alternative forms of labor. As a result we have attempted, as much as possible, to maintain comparability with the cost measurements and coverage of the Enlisted and Officers Billet Cost Models (EBCM and OBCM). Also implicit in the first type of CBCM usage is the ability to make cost comparisons between capital and labor in the same manner as the EBCM and OBCM. Due to its underlying importance, the topic of BCM comparability is discussed at various stages throughout this report.

The second major category of use is most commonly referred to as force structure analysis. Here the CBCM is used to study such issues as pay, occupational, or grade structure of broad personnel segments within the Navy. In this case the objective is more often budgetary analysis than economic decision-making. The CBCM has been designed to provide the user with the flexibility to deal with either of these issues.

Comparability Issues

In developing the CBCM a primary concern has been to create a model which will provide cost estimates which are analytically comparable to those generated by the other BCM's as well as by civilian contractors. Only then can unbiased labor substitution decisions be made. In several areas, further research will have to be done, and perhaps policy decisions made, before these objectives can be completely satisfied. In this section we will discuss several impor-

tant problems which are not otherwise covered in the descriptions of the cost elements.

One point of difference in the CBCM is the way in which billet occupants are depicted over time. As it stands, the CBCM is static with regard to individuals serving in a particular billet. Much of the detail in the military BCM's depends on the aging of a population which enters the force at LOS 0 and rank E-1 or O-1. The CBCM problem is more complex because of lateral hires: the appearance of individuals with LOS 0 at many different grades or pay levels. The progress of individuals through pay levels and from one occupational group to another is therefore more difficult to predict.

Another important comparability issue is the treatment of income tax within the various BCMs. In a review of the EBCM, Eskew suggested that the implicit tax subsidy represented by military allowances should be included as a cost in the model.* Measurements of these tax advantages have been made in the past and found to be significant.** However, when a three way comparison is considered between military, civil service and contract labor it is not clear how the implicit tax subsidy should be treated.

For purposes of comparability, tax adjustments could either take the form of increases in military costs (as Eskew suggested) or

* Eskew, H., et. al., "Naval Manpower Costs and Cost Models: An Evaluative Study," ASCR-119 Administrative Sciences Corporation, Alexandria, 1978.

** Canby, S. and R. Butler, "The Military Manpower Question," in Arms, Men, and Military Budgets: Issues for Fiscal Year 1977, Crane, Russak, New York, 1976, pp. 183-184.

decreases in civilian costs measuring the additional net contribution or refund to the Treasury when civilian employees are paid. From the viewpoint of the government, however, the economic cost criterion would imply a much more arduous computation: costs net of all contributions through both private and business income taxes. Although such computation would at least be possible for military and civil service personnel, the diversity of contractor firms and their respective tax situations makes similar adjustments infeasible.

The issue of tax adjustments is further complicated by the fact that consideration should be given not only to the implicit tax subsidy for allowances but for all income in kind--none of which is subject to tax.*

Due to the complexity of the income tax issue and the lack of information on the net effects involved, we have chosen to make no adjustments in the CBCM.

Data

The data base for the CBCM was developed from a variety of sources. The most important of these were the Defense Manpower Data Center (DMDC) Master and Training Files and a variety of published and unpublished papers by the Office of Personnel Management (OPM)

* As noted in an earlier Assessment Group paper, problems in the valuation of service-owned capital stock makes imputation of rental values for on-post quarters or other facilities a difficult proposition. See "Navy Officer Billet Cost Model Revision," AG-J158, The Assessment Group, Santa Monica, 1979, pp. 15ff.

of the Civil Service Commission. The DMDC files provided specific data for every member of the Navy's civil service, while the OPM publications yielded age-specific data for the civil service as a whole. Several other sources were used in the development of the data base. A complete list may be found in Section 5.3.

In every case, the elements in the CBCM data base have been processed before being added to the formal data set. In some cases, the processing was simple, e.g., base pay is a mean for all people appearing in a given cell. In other cases, like retirement cost, the underlying computations are quite complex.

The data base consists of four types of variables. There are constants including both single valued cost elements (e.g., per capita overhead) and computational constants such as the discount rate. Recruiting hours are entered as a vector by GS level. Disability benefits are entered as a vector by major occupational group (MOG). The remaining variables, seven in all, are arrays of size GS by FOG (18 x 92). Of the seven arrays, five are dollar costs and two are manhours. The manhours are downtime totals associated with training and general downtime.

Three kinds of values are combined to estimate total billet costs. These are cost element dollar values, downtime hours of individuals in a given cell, and recruiting downtime worked by individuals in other cells as a consequence of the billet in question. That is, recruiting time costs are associated with billets at a higher GS level. The general method for obtaining all costs

internal to the billet is to inflate the sum of dollar values by the ratio of 2080 hours to "up" time hours (i.e., 2080 minus downtime hours). This amounts to calculating the actual per hour dollar costs and multiplying them by the number of hours in a full-time year. After this adjustment is made, a per hour billet cost is computed and recruiting downtime costs from the appropriate GS level are added to the billet's cost.

The model had to be formulated without data on interbillet turnover rates. In every other case, this problem could be finessed by some alternative computational method. For recruiting costs, however, this was impossible.* As a consequence, the interbillet turnover rate is set exogenous to the model as an arbitrary constant. The published tables utilize a rate of 20% per year, corresponding to an average duration in the billet of 5 years. The rate is quite variable over the GS levels and occupational groups. A sensitivity analysis indicated generally a small, though not insignificant, response to large differences in the rate.

The calculations described thus far yield two values: an annual billet cost (including recurring recruiting cost) and an initial cost to establish the billet. These values and each of the

* This is due to the significance of the recurring cost element. Relatively large amounts of time are required, by people of one or two GS levels above the billet, to screen, interview and hire people to keep a billet filled. It was decided that an arbitrary value would be more useful to the general goals of the model than to ignore the element entirely. Note also, in the discussion of training costs that no evidence could be found to justify training costs as investments in human capital. Hence, interbillet turnover rates were unnecessary for the training cost element.

cost elements are recorded in the published tables, one for each FOG.

A variety of discounting patterns are used in the model. Two discounting methods are used to recognize the two dominant time patterns in which costs are incurred. Base pay and employer tax contributions, like FEGLI, are discounted by two week intervals corresponding to pay periods. All other cost elements, with the exception of retirement obligation accrual, tend to occur at random intervals throughout the year. Retirement obligation increases with real time increases in LOS and age. For cost elements normally occurring at random intervals during the year, discounting is done from mid-year points on the assumption that they will be evenly distributed throughout the year. Retirement costs are discounted at two week intervals, like base pay, to acknowledge their real time character. However, the cost itself is estimated as an annual quantity and distributed evenly into two week components.*

The discount factor used for bi-weekly costs is:

$$(4.1) \quad s = i^{-1} [1 - (1+i)^{-n}] ,$$

where i is the annual discount rate divided by 26 and n is the number of two week periods in the life cycle. The value of s is the discounted present value of \$1.00 paid every two weeks over n periods.

* Annuity payments are discounted to present value on a monthly basis since they are paid that way.

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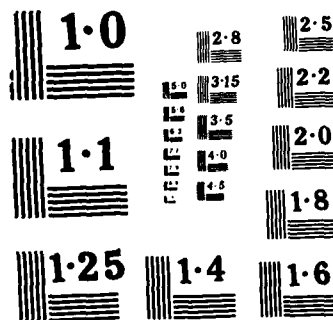
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MICROCOPY RESOLUTION TEST CHART

The discount factor for annual costs, incurred at midyear, is similar:

$$(4.2) \quad s' = d^{-1}[(1+d)^{.5} - (1+d)^{-n'+.5}]$$

where d is the annual discount rate ($d=.261$) and $n'=26n$. Therefore the sum s' equals the discounted present value of a stream of \$1.00 costs incurred at midyear over a period of n' years. In both instances the discount factors are multiplied by a single number to yield the life cycle cost of a given element. In the case of s , it is multiplied by the biweekly cost and in that of s' by the annual cost. These values are then added together for the life cycle cost. Several values of s' are published at the beginning of the volume containing BCM outputs to allow users to convert a one-year cost into any desired life cycle cost at a variety of discount rates.

4.2 TECHNICAL DESCRIPTION OF THE COST ELEMENTS

This section provides an element-by-element description of the billet cost model. Each element's computation, data sources and theoretical problems is discussed in order. In some cases, these discussions are simple, base pay for example. In other cases, the discussion is quite lengthy and complex. The computation of retirement costs, for example, has absorbed a disproportionate amount of time and computational resources in this model. On the other hand, training costs, which are quite difficult to compute in the military models, are trivial in the civilian model. The reason, of course,

is related to differences in the management of the two groups: lateral hire is the rule for civilians while bottom entry is the rule for military people. The differences in importance and quantity of training flow from this difference in personnel management.

4.3 BASE PAY

Base pay in the CBCM is based on data in the most recent end-of-fiscal-year DMDC Master File covering all civil servants employed by the U.S. Navy, both in the United States and abroad. Base pay is set in two ways. The general schedule is applied to white collar workers and includes 18 major divisions (grades), each of which contains 10 subsidiary divisions (steps).^{*} The second basis for setting pay rates is applied to wage board employees--government blue collar workers. Rate schedules are devised for every local area in which wage board employees are hired so that wage rates can be made competitive in local labor markets.

In addition to regional variations, wage board employees are classified in one of 26 pay plans. Most of the pay plans are a result of special union wage scales or specific laws governing the compensation of workers employed in overseas regions. There are 6 pay plans of interest in the CBCM. These apply to 1) apprentices, 2) general workers, 3) wage leaders, 4) supervisors, 5) non-supervisory scheduling employees and 6) supervisory scheduling employees. In general the wage schedules are higher for each group in

^{*} The CBCM does not cover Executive Level positions. Nor does it cover per se, the Senior Executive Service introduced by the Civil Service Reform Act of 1978 (PL 95-454, Oct. 13, 1978).

the order given. Among all other pay plans, only a few are represented at any depth in the Navy. These other pay plans were reclassified to fit into the six pay plans named and plans 4 and 6 were combined, leaving five categories in sum. Because the pay schedules (and personal characteristics) of individuals in the same FOG but different pay plan groups were so dissimilar, each blue collar FOG is broken down into the five pay plan aggregates. Thus, vehicle operators (FOG 80X) have been broken down into five separate occupational groups including apprentice vehicle operators, general vehicle operators and so on. This removes the statistical problems associated with treating aggregates of dissimilar classes and allows greater specificity in the output of the model.

There are two special pay plan groups which appear in only one FOG each. These are lithographic production workers (FOG = 795) and marine vehicle operators (FOG = 805). They do not fit comfortably into any of the five aggregates described above and have been defined as special occupational groups falling within their appropriate FOGs but outside the pay schedule scheme of apprentice, general laborer, supervisor and so on. As a result of these groupings, the CBCM performs computations for a total of 92 occupational groups. Of these, the first 25 are white collar categories as defined by the DMDC's Functional Occupational Group (FOG) codes and the remainder are blue collar groups in which the third digit indicates the pay plan aggregate. In the balance of the report, unless an explicit distinction is made, references to FOG or FOG/grade cells pertain to these 92 occupational groups.

Within each FOG, workers are classified by GS level and step.* The basic analytic unit adopted for the CBCM is the FOG/grade cell which includes all workers in a particular FOG and grade. Base pay is therefore the average base pay for members of a cell. Depending on the step distribution characterizing a given cell, average income therefore varies between FOGs for the same GS level.

For wage board employees, there is an additional source of variation within each cell. For individuals within the same occupational group, grade and pay plan, wages will differ depending upon the location of the billet. The average base pay calculations for wage board employees, therefore, is in fact a weighted average based on the distribution and size of wage area differentials within each cell. There are 138 wage areas covered in our data base as well as many non-U.S. areas, all governed by different wage schedules for the various grades and pay plans. Our research revealed that there is no simple relationship between these schedules--i.e., New York City wage schedules are not simply 15% higher than Norfolk for all pay plans and grades. Each schedule is locally determined by existing competitive conditions for each type of worker. We felt that the uses of the CBCM would not require specific locational data and therefore, given the volume of data involved, we opted for the current aggregate approach as a more useful one.**

* Again, pay levels are called WS levels for wage board employees, but this distinction is ignored in the text unless explicitly noted.

** For wage areas of special interest, such as Washington, D.C., an additional analysis of the master file could easily be completed to identify the exact wage levels.

4.4 PREMIUM PAYS

Premium pay data were obtained from special analyses prepared by the personnel departments at the Long Beach Naval Shipyard and the Naval Air Rework Facility, San Diego.* The analyses provide detailed information on the distribution and number of premium hours worked for each grade (GS and WS) in the facilities in question. While not strictly representative, especially in the case of white collar workers, they provide a sound basis for a preliminary computation and indicate a feasible method for the future. The additional source of data is the Navy Comptroller's Office which provided us with 1979 summary data on total Navy expenditures in each of the premium pay categories, broken down by wage board and GS employees.

The general approach to this cost element is to distribute the total budget cost of premium pays between GS and wage board grades on the basis of the sample distributions from San Diego and Long Beach. This can be done separately for three types of premium pay: overtime, holiday and Sunday premium.** The first is paid at one and a half times base pay and the second and third are twice the base pay rate.

For each pay system, the sample data provide a direct measurement of $h(g)$ which is the average premium hours per man in grade g . The base pay rate, $w(g)$, is known from the base pay computation

* We would like to give special thanks to Dr. Ernest Koehler, NPRDC, for his assistance in arranging for these data to be produced.

** Other premium pays such as nightwork differential, hazardous duty, and overseas differential were distributed on a per capita basis.

discussed above. The product of these two values, the premium rate, and the number of workers in the appropriate population at that grade, $N(g)$, yields a hypothetical total premium pay in grade g :

$$(4.3) \quad P(g) = 1.5h(g)w(g)N(g) ,$$

where $N(g) = \sum_{f=1}^{f_1} n(f,g)$, or the sum of workers in each FOG at grade g .

The number of FOG categories in the appropriate population is f_1 .

If $P(g)$ is then summed over all grades, we have a hypothetical total premium pay, s , for the entire appropriate population. Note that both s and its components $P(g)$, are hypothetical: they will be either larger or smaller than the actual amount spent on premium pay (B), depending on the overtime behavior of the sample relative to the Navy as a whole. We therefore convert the $P(g)$ into an index number series:

$$(4.4) \quad I(g) = P(g)/s.$$

The index can be defined as the proportion of B paid to the group of workers in grade g . Therefore, the product $I(g)B$, if divided by $N(g)$, yields an estimate of the per man cost of premium pays. Combining the three kinds of premium pays (B_1 : straight overtime, B_2 : holiday premium and B_3 : Sunday premium), gives an estimate, by grade, of all premium pays:

$$(4.5) \quad B(g) = [B_1I_1(g)+B_2I_2(g)+B_3I_3(g)]N(g)^{-1} .$$

This equation is applied five times for different populations of workers. These include all general schedule employees and the five

pay plan groups of wage board employees (i.e., general labor, supervision, etc.).

4.5 RETIREMENT

The Civil Service Commission administers several forms of retirement benefits financed through the retirement fund. The principal income of the fund is a compulsory contribution by civil service employees, currently amounting to 7% of base pay. Benefits include a regular retirement policy, disability retirement, survivor policies and the ability to cash out of the policy at any time before receiving retirement payments. The last option is called a lump sum settlement.

The computation of retirement costs is separated into two general parts: contributions and disbursements. In the billet cost models, the government's eventual obligation to cover an employee's retirement annuity is costed over the years of the employee's service. The government's eventual obligation is the difference in value between the amount required to fund an average (billet) employee's retirement annuity stream and the size of the fund accrued with interest by the Civil Service Commission from the employee's biweekly mandatory contributions (from his pay packet). This eventual obligation is costed out over the period of service by means of a level payment funding scheme. Given that a current employee will retire--as opposed to other modes of separation from the service--the regular retirement cost incurred by one year of service is just this. (The regular retirement billet cost is the product of this

with the probability of eventually retiring.)

Each of the funds is the result of several complex computations and, unfortunately, a number of important assumptions. All computations are carried out for a unit of analysis, constructed for the purpose, called a retirement computation unit or RCU. Each billet contains, potentially, six RCU's made up of three LOS groups by sex. This was necessary because of the great difference in several important parameters by sex and the importance of length of service. The value appearing in the CBCM for retirement is a weighted average of the six RCU's, the weights being proportional to the number of employees in each. The discussion below addresses the computation for a single RCU of which there are approximately 3000 in the data base.

Looking Backward: The Employee's Contribution Fund

Since the early 1940's, contribution rates have varied from 5% to 7% of an employee's salary. Over the same period CSC yield rates have varied from about 3.5% to 5% and obligation interest rates (guaranteed to leaving employees requesting refunds) have dropped from 4% to zero. The history of these rates is shown in Table 4.1.

The wage history of individuals found in the cross-section data base is, of course, unknown. In order to estimate the dollar value of contributions, therefore, it was necessary to base the wage history on a growth rate of wages. Since the size of the various funds is extremely sensitive to this variable, it can be changed through the interactive portion of the CBCM software. The rate used in the published tables is 2% per annum.

Table 4.1: Contribution Statistics

PERIOD	CONTRIBUTION RATE	GUARANTEE RATE	CSC YIELD RATE*
up to 31 Dec. '47	.05	.04	.05
1 Jan. '48 to 30 Jun. '48	.05	.03	.04
1 Jul. '48 to 31 Oct. '56	.06	.03	.04
1 Nov. '56 to 31 Dec. '56	.065	.03	.04
1 Jan. '57 to 31 Dec. '69	.065	.00	.035
1 Jan. '70 to present	.07	.00	.05

* Estimates based on CSC Retirement Commissioners Annual Reports.

The algorithm used to estimate the size of a fund works backward in three units of time. First, contributions and their accrued interest are registered at each 2-week interval. Second, wage changes occur every year. Third, contributions and interest rates change during each of the periods (called intervals) shown in Table 4.1. The intervals represent a fixed time line along which a given RCU's history is projected, anchored at midyear, 1983. For each interval, the value of the contribution fund is given by:

$$(4.6) \quad F_j = \prod_{q=1}^{j-1} \left[\left(1 + \frac{i_q}{26} \right)^{26P_q} \right] \sum_{q=0}^{j-1} \left(1 + \frac{i_j}{26} \right)^q \frac{2+\rho}{2(1+\rho)^{x_j}},$$

$$\text{where } x_j = \left[\sum_{q=1}^{j-1} P_q + \frac{q+1}{26} \right] \text{ and the variables are:}$$

i_q = annual interest rate in q^{th} interval.

ρ = annual real growth rate of wages.

P_q = number of years in the q^{th} interval.

Equation 4.6 is evaluated for each of the six intervals covered by the average LOS of a given RCU and the results are summed to find the size of the contribution fund at retirement.

The reader should note that the same methodology is used to compute the lump sum settlement returned to a separating employee; the only change is that the guaranteed interest rate is used instead of the CSC yield rate.

Looking Forward: Present Cost of Alternative Retirement Streams

The value of the retirement stream is, in fact, a weighted average of the costs associated with the eight ways in which an individual may leave the civil service. The weights are their respective probabilities of occurrence. The costs are defined as the funds necessary to finance each cost stream:

- F₁: Regular retirement for an employee with survivor benefits (used for males only).*
- F₂: Regular retirement without survivor benefits.
- F₃: Deferred retirement with survivor benefits (males only).
- F₄: Deferred retirement without survivor benefits.
- F₅: Disability retirement with survivor benefits (males only).
- F₆: Disability retirement without survivor benefits.
- F₇: Death during service with survivor benefits (males only).
- F₈: Lump sum settlement (death without survivors and cashout options combined).

* Since female expectations of life always exceed those of males, the computational technique would yield no difference between F₁ and F₂ except a lower initial annuity.

Slightly different rules obtain for each of the options mentioned and these are reflected in the algorithms used to compute costs.

For F_1 , F_3 and F_5 , two cost streams are computed, one for the employee, the other for the survivor.

Regular retirement occurs in the model when an individual's age reaches a computed expected age of retirement. For all other cost streams (F_3 to F_8), the stream begins immediately and its full cost is weighted only by the probability of that type of event.

Computation of the discounted present cost of any retirement stream is accomplished through rearrangement of the level payments formula to solve for the size of the fund given the size of payments. The relation is:

$$(4.7) \quad F_j = \frac{A[1-(1+i/12)^{-b}]}{i/12},$$

where i is the CSC annual yield rate on investments and b is the number of months during which an annuity will be paid.

Equation 4.7 is used twice in F_1 , F_3 and F_5 and once for the other retirement options. The parameters A and b take on different values for each computation: one set of values for F_2 , F_4 , F_6 through F_8 and two sets for F_1 , F_3 and F_5 .

Net Costs of a Given Year

When an individual leaves government service, he receives money from the retirement fund, the amount varying as a function of the

conditions of departure. If the conditions are such that all of the accrued value of the employee's contributions is not required, two things may happen: either the full balance reverts to the government or a portion of it goes to the individual or his estate. The simplest case is that of a cashout. The individual gets the (accrued) value of his contributions at the guaranteed (lower) interest rate but the balance reverts to the retirement fund. If an annuity stream is paid but, for example, ends early, anything left goes to the estate of the deceased. In this event the retirement fund also gets the difference. Finally, if the accrued value of contributions is exceeded by the value of disbursements, the difference represents the net cost to the government of that individual's retirement.

Thus we may compute, for each mode of employee separation an amount, F_i the government must add to (or remove from) the value accrued from employee contributions. Each of these amounts F_i , representing a net cost to the government if such a course of separation is followed, is converted into the corresponding annual level payment, C_i that would be required were the government to grow a fund during an employee's service (at 10% interest) to cover this net amount.

$$(4.8) \quad C_i = F_i \cdot [(1+i)^{-1} + (1+i)^{-2} + \dots + (1+i)^{-N}]$$

where N is the number of biweeks before he separates and i is the biweekly interest rate corresponding to a 10% annual rate. Finally the costs C_i , for specific options are combined in a weighted sum to provide average RCU costs:

$$(4.9) \quad C_{RCU} = \sum_{i=1}^8 C_i W_i .$$

Each of the weights, W_i , is a combination of the probabilities of two events: the probability of survivor coverage or lack of it and the probability that the respective mode of separation from the service will occur. In the case of C_1 and C_2 (regular retirement), a third probabilistic computation is required to estimate the expected age at retirement. The probability of survivor coverage was provided by the Chief Actuary, CSC Retirement Fund Board of Actuaries. The probabilities of events 3 through 8 are provided as single year of age probabilities of death, disability and separation published by the Board of Actuaries and based on a continuous 10 per cent sample of civil servants obtained during the period 1966-1968. These are the most recent records available.* In addition, a special study of separations conducted during 1967 provides the only available data on the probability that an individual will cash out upon separation (rather than elect deferred retirement). The weights are shown in Table 4.2.

The probability of eventually retiring, the weight associated with the regular retirement level payment, is calculated as the probability of not separating in another way before retirement eligibility is vested. The length of the period before vestment is a function of both current age and (effective) age at entry. For

* As of Spring, 1983 new demographic statistics are still unavailable.

Table 4.2: Retirement Option Weights

		<u>Weights</u>	
	<u>Type</u>	<u>Males</u>	<u>Females</u>
C ₁	Regular W/SSA	.703 R _t	-
C ₂	Regular	.297 R _t	f _{R_t}
C ₃	Deferred W/SSA	.703 D _t	-
C ₄	Deferred	.297 D _t	f _{D_t}
C ₅	Disability W/SSA	.703 Z _t	-
C ₆	Disability	.297 Z _t	f _{Z_t}
C ₇	Death W/SSA	.703 S _t	-
C ₈	Death or Cash Out	.297 S _t +C _{t,1}	f _{S_t+C_{t,1}}

Variables: D_t: single year probability of deferred retirement for males and f_{D_t}, for females.

Z_t: single year probability of disability for males and f_{Z_t}, for females.

S_t: single year probability of death for males and f_{S_t}, for females.

C_{t,1}: single year probability of separation to cash out, given age (t) and LOS (1).

R_t: the resultant probability of eventually retiring, and f_{R_t}, for females.

Note that .703 is the proportion of males electing SSA coverage.

this period we calculate from the single year probabilities of leaving the service before retirement--those that are appropriate to his increasing age and LOS--the probability of separating before retirement. The result subtracted from one is taken to be the probability of eventual retirement, the weight associated with the regular retirement cost calculated above.

The RCU costs obtained with these weights are then combined into a weighted average retirement cost for a billet. In this step the weights are the number of individuals in each of the (possible) six RCU's belonging to a given GS/FOG cell.

4.6 LIFE INSURANCE (FEGLI)

The primary sources for estimating life insurance costs are the Federal Employee's Almanac, 1983, and the Navy Civilian Master File for end of FY 1982 from DMDC.

Although FEGLI is an optional benefit, most employees choose to take at least the regular insurance coverage. For regular coverage the employee pays 2/3 of the premium and the government pays 1/3. For any additional coverage the employee pays the full amount.

The general rule for regular life insurance coverage is that the level of coverage, C, is equal to \$2,000 plus the employee's yearly salary S, rounded to the next highest thousand. C must be at least \$10,000 and no greater than \$63,000 for regular coverage.

By analysis of the Master File data we determine:

- a) the average salary within each cell (FOG/GS)

- b) the percentage of individuals who choose either regular or additional coverage within the cell (the cost to the government being the same in either case).

From the Federal Employee's Almanac, 1983 we calculate that the employees biweekly premium, P , is equal to \$.255 for each \$1,000 of life insurance coverage. The biweekly cost to the government is half that amount or $P/2$, and the yearly government contribution is $13P$.

The actual computation is as follows:

C - level of coverage

P - biweekly cost to employee

G - annual cost to the government

S - employee's yearly income rounded to highest \$1,000

a - percentage of employees in FOG/grade cell taking regular or optional coverage.

$C = S + 2,000$ constraints on C : $10,000 \leq C \leq 63,000$

$P = .255C/1,000$

$G = 26P/2 = 13P$

Expected Life Insurance cost (FEGLI) = aG .

4.7 TRAINING COST

Sources for training cost estimates were the Master and Training Files of the DMDC, Monterey. The Training File provided data for 1980 while the Master File treats 1982. Adjustments had to be made to accommodate the differences in dates. In addition, the 1980 Master File was used for certain adjustments.

It was first necessary to obtain occupational group data from the 1980 Master File because these were unavailable on the Training File. This was done by matching social security code numbers (SSNs) and merging the required data on a new file. Because the Training File pertains to a slightly different time period than the Master, matches were achieved for only 95% of the observations on the Training File. On the implicit assumption that the distribution of excluded training was equivalent to that of the training included in the match, the latter was inflated by dividing by .95. This factor was applied both to hour (H) and dollar (TC) figures by GS/FOG cell.

The second adjustment was to compensate for all size changes from 1980 to 1982. Let the cell size in these years be N_{80} and N_{82} . Since both equations must be corrected to a per capita basis, the N_{82} drops out completely, giving:

$$(4.10) \quad X_4 = TC / (.95N_{80})$$

and

$$(4.11) \quad H_1 = H / (.95N_{80}).$$

No computation was necessary to obtain the value H since it is a variable (duty hours spent training) in the Training File. Several manipulations were required to obtain TC (training costs), however. It was initially our intention to distribute training costs over time in a manner consistent with amortization of human capital. Evidence from the file indicated this to be inappropriate, however.

Therefore, only a "raw" training cost total per GS/FOG cell was required.

The Training File, once merged with the Master File through SSN codes, provides several variables including on-duty hours, off-duty hours, and tuition costs (called direct costs). The tuition costs can also be matched to a training source code. These codes indicate whether the course was provided by the agency in question, by another government body, by an outside contractor who designed the course specifically for the government, or an outside contractor or institution who offered the course to anyone.

Preliminary processing of the tape indicated that the cost of tuition per hour was quite low for government supplied courses. On the theory that outside contractors' tuition costs would more accurately reflect the real resource costs involved in delivering a training course, we developed per hour tuition cost estimates on the basis of outside courses only (source codes 3 and 4 in the Training File). Despite the large improvement in the data series resulting from this selection, there was still a great deal of variability, with many per hour values appearing unrealistically low. As a consequence, we ended by aggregating to the major occupational group (MOG) level. MOG's consist of all the Functional Occupational Groups bearing the same first digit. The hourly cost of tuition (for these groups) was found to be as shown in Table 4.3. When these values are multiplied by the sum of on- and off-duty hours (by GS/FOG), the result is total tuition costs by GS/FOG cell.

Table 4.3: 1980 Tuition Cost Per Hour
by Major Occupational Group

<u>MOG Code</u>	<u>Title</u>	<u>Tuition Cost per Hour</u>
1	Scientists and Engineers	\$12.41
2	Other Professionals	11.30
3	Management and Administration	9.31
4	Technicians and Subprofessionals	8.22
5	Clerical	5.53
6	Service	2.58
7	Craftsmen, Mechanics, and Production	7.55
8	Laborers and Operators	5.66

This amount was added to the total of indirect costs (travel and subsistence costs) and the sum adjusted by the rise in prices from 1980 through 1983. The equation for TC is:

$$(4.12) \quad TC = tc(H+H') + ic \prod_{j=1980}^{1983} (1+CPI_j) + X_{10}H/2080 ,$$

where tc is the MOG per-hour tuition cost, H is on duty hours, H' is off-duty hours, ic is indirect cost and CPI_j is the proportional increase in the Consumer Price Index for the year j . Finally, H , is also costed at the trainee's hourly billet cost and added to the other costs of training.

Discussion

The major problems in the training account occurred in predicting accurate tuition cost estimates and determining an appropriate amortization scheme. The first problem was easily solved by adopting the argument that outside suppliers would tend to charge tuitions reflective of real resource costs. These rates were applied

to the length of every course, irrespective of who provided it. It was felt that other directly measured dollar costs (called indirect cost in the Training File documentation) were probably measured correctly since they include items which the government must reimburse to the student, such as travel and subsistence costs.

An appropriate amortization scheme presented a more difficult problem. Simple statistical analysis revealed no basis for the theory that training expenditures represented investments in human capital, to be recovered over subsequent periods of service. In the absence of such evidence it was decided that, at least for the moment, amortization could be dispensed with on the notion that training represents some form of non-pecuniary income and, as such, is a current cost.*

Nevertheless, this is an unsatisfying conclusion. While some training can be imagined to fill the role of employment inducement and reward of service, this is certainly not true for all training. What is particularly disturbing is the feeling that training-as-income is a practice confined to certain occupational groups and GS levels. The most reasonable hypothesis (for which only impressionistic evidence is available) is that training-as-income is a practice reserved for the higher grades of professional and technical occupational groups where other elements of pay (e.g., base pay) may be insufficient to attract and retain qualified personnel. Training-as-investment, on the other hand, is likely to be more prevalent

* We would like to thank CDR Mairs for first suggesting this possibility. As noted, subsequent analysis could not refute his hypothesis.

for lower grades, especially where employee turnover is expected to be relatively low.

In many cases, however, these two types of training will be intermingled. Both the statistical analysis and the data needed to decompose these two elements is quite beyond the scope of this initial CBCM effort. Nevertheless, to undertake that analysis is an important future task for research. There are two reasons for this. First, the training element is of significant size in the CBCM, especially for some GS/FOG cells. Second, it is one of the elements (once income and investment components can be separated) of billet cost capable of displaying significant variation between different types of workers.

If decomposition of the two uses of training is achieved, then their treatment is straightforward. Training-as-income is a current cost similar to any other benefit. Amortization would appear to be inappropriate in this instance. Training-as-investment should be amortized over its useful life. On the theory that most of the latter is job specific, determination of useful life would require either an inter-billet turnover rate or an inter-occupation turnover rate. Once determined, these could be used to spread the training cost over those years following training during which an individual is expected to remain in the billet or occupation for which he was trained.*

* An alternative position would be that the cost be amortized over an entire career on the theory that it adds slightly to the recipient's general value to the Navy. This is, in fact, the recommended procedure for training in the Officer's BCM. To do so requires a man-based model, however, rather than a billet based model.

4.8 RECRUITMENT

Recruiting costs include initial and recurring elements. Initial costs are those involved in establishing a new billet-- preparation of the Position Description, obtaining budgeting authority and so on. Recurring costs include advertising of an opening, consideration of resumes, interviewing applicants and selection and preparation of the formal offer. There are virtually no data available through either the DMDC or any other group in the Navy (or the Civil Service) which measure these costs. From the Civil Service Commission we have been able to obtain a gross estimate of per capita screening costs for new personnel. Virtually all other costs mentioned above, however, are borne by Navy personnel and are not reflected in the screening cost element.

Faced with a cost element we knew to be of some significance, but because of the unavailability of data, we decided to make a rough estimate based on interviews with personnel officers at three Navy installations (the Naval Personnel Research and Development Center, San Diego, the Naval Air Research Facility, San Diego and the Long Beach Naval Shipyard). While recognizing this as an entirely inadequate basis for developing reliable estimates of the relevant values, the interviews did provide us with enough information to structure the cost relations. In addition, we used the testimony obtained to fill in the parametric requirements of the formulation. Its significance is, therefore, indicative of the costs to be anticipated from this source rather than authoritative with regard to their absolute values.

The computation uses two variables, IH_1 and IH_2 , the number of hours required to set up a billet and the number required to fill a vacancy. Both variables are vectors, dependent on the GS level of the billet to be created or filled. The hours themselves are valued at the full billet cost of the GS level expected to perform the administrative labor. Values used for IH_1 run from one hour for GS-1's to 6 hours for super grades (GS-16 to GS-18). Values of IH_2 run from two hours to 46 hours over the source range. Each billet is costed at billet cost two grades higher in the same FOG.

For wage board employees a different method is used. Because each FOG was broken into five components related to hierarchical employment status, it was necessary to cost recruiting time across FOG (pay/plan) groups. The scheme of time valuation is as shown in Table 4.4.

Table 4.4: Wage Board Recruiting Responsibility
by Pay Plan Aggregate

<u>Billet to be Filled</u>	<u>Billet Used for Time Cost</u>
Apprentice	Leader
General	Leader
Leader	Supervisory, Sched.
Non-Supervisory, Sched.	Supervisory, Sched.
Supervisory, Sched.	by WS-level: two grades higher
Special FOG*	Supervisory, Sched.

* Two special 3-digit occupational groups: see discussion of base pay above.

For the computation of recurring recruitment cost, it is necessary to estimate the frequency with which the billet must be filled during its life cycle. This, again, was a crucial value for which no direct data could be obtained. Rather than attempt to create an estimate based on inadequate information, it was decided that the inter-billet turnover rate would be left as an exogenous variable, allowing the user to choose a particular value. The formulation for the recurring recruiting costs element is:

$$(4.13) \quad X_8(K) = \left[\frac{X_{10}(K')}{2080} \right] IH_2 \cdot TOR ,$$

where TOR is the annual inter-billet turnover rate and K and K' are the GS levels of the billet being costed and the billet responsible for interviewing, respectively.

The recruitment computations are initiated for both the general schedule employees and the wage board supervisory employees by costing the highest grade first. That is, GS-18's interview GS-18's and WS-18's interview WS-18's. This is done in the same manner as downtime costs: billet cost without interview time (i.e., IH_2) is converted to an hourly cost per hour with IH_2 included. The result is multiplied by 2080:

$$(4.14) \quad X_{10} 2080 / (2080 - IH_2 TOR) ,$$

where X_{10} is billet cost excluding recruiting cost. The full billet cost is then divided by 2080 to yield an hourly rate to be applied to lower GS levels. The scheme is as shown in Table 4.5.

Table 4.5: GS Recruiting Responsibility by Grade

<u>Grade to be Filled</u>	<u>Grade Used for Time Cost</u>
1-5	7
6	8
7	9
8	10
9	11
10	12
11	13
12	14
13	15
14	16
15	17
16-18	18

Each lower grade is costed after the responsible grade estimate has already been obtained. After the top grade is computed by the inflator technique described above, lower grades are costed by direct addition of labor costs:

$$(4.15) \text{ Full Billet Cost(GS=17)} = X_{10}(\text{GS=17}) + \frac{X_{10}(\text{GS=18})}{2080} 1H_2\text{TOR} .$$

This procedure is followed for all general schedule employees, but only for the supervisory groups among wage board employees. Subsequently an average hourly full billet cost is computed for supervisory employees and used as the hourly cost of interviewing for non-supervisory scheduling employees, wage leaders and the special FOGs. The same computation (average for the entire group) is made for wage leaders and then used for general workers and apprentices. The cost of setting up a new billet is given by:

$$(4.16) \text{ Initial Billet Cost(GS=K)} = RD + (IH_1 + IH_2) \frac{X_{10}(K')}{2080} ,$$

where, as before, K and K' are the GS levels of the billet being costed and the billet responsible for interviewing, respectively. RD is the per capita screening cost, a one time cost incurred by the Navy when a new employee enters the civil service. The value of RD is independent of FOG or grade level. When setting up a low grade level billet, it is likely that the new employee is entering the civil service for the first time. In the case of higher grade billets, often the person who enters the new billet will not be new to the civil service, but a civil servant who has been promoted. In this instance, a vacancy will be created elsewhere in the civil service, necessitating the induction of new personnel. Another situation is not reflected by the initial billet cost computation. That is the case where the employee filling the billet leaves the civil service. In fact, the factor RD should be replaced by $RD(1+P_s(\text{FOG/GS}))$, where $P_s(\text{FOG/GS})$ is the billet specific probability of separation for any cause (e.g., death, disability) from the civil service. This refinement will be added to future versions of the model.

Discussion

The conceptual basis for the recruitment cost element is that time spent in creating and filling job vacancies is an additional (marginal) cost. We were initially hesitant to take this approach because it seemed to produce a double count of wage cost for the interviewer. In other words, if we treat time spent in recruiting as downtime when the individual is merely carrying out routine duties, we have counted hours spent that way twice.

The rationale for doing so rests on the notion that, while interviewing may be one of a worker's normal activities, the creation of a new billet adds to those duties. We implicitly assume that the existing administrative staff is equipped to handle turnover engendered by existing billets. Therefore, unless the assumption were made that all supervisory workers were underutilized, servicing of the new billet will have to be done at the expense of some other work. That is, an opportunity cost is created by the loss of other output.

The opportunity cost mentioned is particularly important since it is borne at a higher wage rate than that of the billet just created. In effect, we are trapping a small part of the indirect personnel costs associated with the creation of a new billet. There are many other indirect costs not accounted for in the model, such as management and direction of the employee.

Despite advice to the contrary, the billet cost models have generally rejected the practice of estimating indirect or support personnel cost as part of an individual billet.* The idea is that the need for such labor can be estimated directly through an additional billet. The problem, of course, is that this is never done unless the number of new billets is sufficiently large to allow estimation of a discrete number of managerial or supervisory personnel (i.e., in large force structure analyses).

The method suggested here offers a compromise between two extreme positions and, we believe, an appropriate computational

* See the discussion in Eskew, op cit, Recommendations.

technique for estimating the more comprehensive indirect costs automatically.

The value of IH_2 could simply be expanded to include all other costs of line management and administration currently ignored by the model. This would resolve some of the inconsistencies remaining in the BCM structures as they are currently formulated. These inconsistencies are created by the fact that a great deal of administrative (if not managerial) cost is already included in all the BCM formulations.

This suggestion is especially compelling when one considers the question of comparability between military, civil service and contractor cost estimates. If, for example, the management of each labor-type is based on radically different spans of control (the average number of subordinates per supervisor), indirect labor costs will vary pari passu. This will also be the case in distinctions between occupational groups within the CBCM.

We have not gone the full distance in estimating these costs for two reasons. First, comparability with the military models would suffer greatly and second, the research required is far from trivial. It should be noted, however, that the least controllable cost estimating form of the three types of labor--contractor labor--incorporates these estimates as a matter of course, both as bidding rates and as elements of direct labor cost which raise the average cost of a manyear.*

* Recruiting time costs are considered double counting for some applications of the CBCM. They, along with all other downtime costs can be suppressed in model runs.

The second topic that requires some discussion is the use of an arbitrary inter-billet turnover rate. As explained above, this was done simply because to use nothing at all would fail to account for significant costs.

The sensitivity of the model to turnover rate is measured by taking the partial derivative of total billet cost with respect to turnover rate. That is:

$$(4.17) \quad \frac{\partial X'_{10}(K)}{\partial \text{TOR}} = \frac{X'_{10}(K')}{2080} \text{IH}_2 ,$$

where K and K' are the GS levels of the billet being costed and the billet responsible for interviewing, respectively. This means that the rate of change in total billet cost with respect to turnover rate is equal to the full cost of filling a billet vacancy. The value of this partial derivative, in the case of FOG 10, GS-14 is \$1,080. That is, IH_2 hours of a FOG 10, GS-16 cost \$1,080. As the turnover rate varies between zero and one, therefore, the contribution to total billet cost will vary between zero and \$1,080.

4.9 INJURY BENEFITS

The primary data sources used to estimate injury benefits are the Navy FY '80 Injury Report, by Cause/Occupation and the Department of Navy Manyear and Cost Report, FY '82. Employee population counts, obtained from the 1982 Master File (DMDC), were also required.

The cost element described in this section is not to be confused with the disability benefits paid to eligible employees under the Civil Service Retirement Act. With few exceptions, compensation for disability cannot be paid concurrently with a disability retirement annuity. Should an individual qualify for both, he must choose one or the other form of payment. The benefits referred to below are commonly known as workmen's compensation payments made under the Federal Employees' Compensation Act (FECA).

Estimation Method

The Injury Report cited above has a breakdown of disability incidence by occupation as well as a total count of injury claims for all Navy Civilians. However, the occupations listed in the report do not coincide with the occupational groups (FOGs) used in the CBCM. As a result, some processing had to be done to identify disability costs with the specific occupations used in the model. After preliminary study it was felt that the Major Occupation Group (MOG) level was more appropriate and reliable than the FOG level for distributing these costs.

The first step in estimating this cost element, therefore, was a complete allocation of the injury incidents (listed on the Injury Report) to their appropriate MOG. To determine the expected cost per incident we simply divide the total disability cost figure (NAVCOMP) by the total number of disability claims on the Injury Report. To obtain the total cost of disability by MOG we then multiply the injury count per MOG by the average cost per incident.

This total cost is then spread over the entire MOG population to obtain an expected cost of disability per man in that occupational group.

Discussion

The method cited above provides one way of reasonably allocating the budgeted disability payments over all Navy civilians. The count of disability claims in each occupational group serves as the criterion for estimating the expected cost in each group. A way of more accurately distributing these claims by subgroup (using FOG's rather than MOG, for example) would be one way of improving these estimates.

These calculations could also be improved somewhat with additional research into the relationship between the extent of injury and the cost per incident of disability. The expected cost of an incident of disability will be a function of the length of the claiming period and the size of the employee's salary as well as the direct costs of treating the injuries. These factors may vary considerably between occupational groups, thus implying a wide variance in the cost per incident. For example, it is probably the case that the average injury claim for a heavy equipment operator is more costly (i.e., of longer duration and requiring more medical expense) than for an office worker.

One alternative allocation method would be based on a weighted average of the type of injuries (i.e., limited, non-limited, death) and the salary level within the occupational group--somewhat analo-

gous to the current scheme for allocating premium pays. We believe that additional research at the Department of Labor would yield the requisite data for this allocation method.

4.10 OVERHEAD COSTS

Overhead costs are those which, due mainly to insufficient information, cannot be allocated to a specific FOG or GS-level and, therefore, are distributed equally among all Navy civilians. All of the components of the overhead pool are costs which are accounted for in the Department of Navy, Manyear & Cost Report FY 82 but are not specifically dealt with elsewhere in the model. The following section is a description of the elements which make up this pool and a discussion of the alternative possibilities for a more precise allocation of these costs.

Health Insurance Costs

The primary sources used to estimate the costs of health insurance were the Federal Fringe Benefits Facts, 1982 and the Federal Employee's Almanac, 1983.*

Health insurance costs, shared by the employee and the government, are a function of the particular plan which is chosen. There are a large number of alternatives available, depending upon the location of the employee, but they all may be classified into four basic categories. For each plan there are generally high and low

* Calculation of the average overhead cost also requires a total employee count derived from the 1982 Master File.

benefit options and within each option the employee may choose either self-only or family coverage.

The contribution of the government towards health insurance is invariant over plans--\$21.27 biweekly for self-only and \$47.54 for family--as long as those amounts do not exceed 75% of the total premium. Since the available data do not permit cost allocation by variables such as FOG, salary, age, or LOS, the approach taken here is to estimate an average (expected) cost to apply to all Navy civilians. To get an accurate estimate of the cost per employee the following series of calculations must be made:

- 1) Determine the breakdown of employees choosing the high vs. low benefits option (Federal Fringe Benefits Facts)
- 2) Within each of these categories, determine the relative number of individuals choosing self-only vs. family coverage (call these percentages P_{hs} , P_{hf} , P_{ls} , P_{lf} with the sum = 100%)
- 3) Determine the plans in the above categories for which the stated government contribution exceeds 75% of the total premium and calculate the actual amount paid.
- 4) For all categories, compute a weighted average premium paid by the government, with the weights equal to the number of individuals enrolled in each plan relative to the total in that category. (Call these amounts C_{hs} , C_{hf} , C_{ls} , C_{lf})
- 5) Now the data can be summarized in a pair of two-by-two matrices which, when combined, give an appropriate expected cost of health insurance.

		High	Low
COST:	Self	C_{hs}	C_{ls}
	Family	C_{hf}	C_{lf}

		High	Low
PROBABILITY:	Self	P_{hs}	P_{ls}
	Family	P_{hf}	P_{lf}

Merging these matrices yields $PC = (C_{hs}P_{hs}) + (C_{hf}P_{hf}) + (C_{lf}P_{lf}) + (C_{ls}P_{ls})$ where PC is the expected biweekly cost to the government. Multiplying by 26 gives the yearly cost.

The method for estimating health insurance costs yields a weighted average obligation using data from all Federal civilian employees, Navy or otherwise. Since the geographic location and the chosen option (high-low, family-self) determine the costs of each plan, this method certainly introduces some unknown bias unless Navy civilians are distributed exactly as all Federal employees. One potential method for more accurately estimating health insurance costs would involve both a demographic and geographic analysis of Navy civilians. The geographic analysis would provide a closer estimate of the distribution of plans chosen while an analysis of marital status (married, number of children) would provide information on the probability of choosing each plan option.* The variance in these statistics would imply different weighted average costs by FOG or FOG/GS cell. Given the wide inter-cell variation in age (as well as marital status and the geographic location) this difference in average cost is expected to be significant.

Severance Costs

Estimates of expected severance costs are derived from the Department of Navy Manyear and Cost Report FY 82.

* Although locational data are available on the master file, marital status is not currently included. Salary level might also be a determining factor.

Like all components of overhead, budgeted severance costs are distributed equally to all full-time Navy civilians. However, there exist specific rules relating to the size of severance payments and a more accurate allocation method would distribute costs as a function of salary, LOS, and the probability of being severed. Salary and LOS are data easily obtained from the master file but the probability of being severed in any occupation or grade would be a very difficult statistic to estimate. Historical data, if available from OPM, may provide some information but even a small change in future policy would produce large biases in the estimates. We believe that the likely benefit from research in this direction would not be worth the cost.*

Permanent Change of Station (PCS) Costs

The primary data source for estimating the PCS component of the overhead pool is the Department of Navy, Manyear and Cost Report FY 82.

There are several possibilities for removing PCS costs from general overhead and allocating them more specifically to different grades and occupations. The expected outlays for PCS in any particular billet is probably a function of a number of interrelated variables including billet turnover, salary level, job location, training, and labor supply conditions in that occupation. Although we now have reliable data on salary levels and job location, data on

* The average overhead cost per person in 1982 is less than \$20 per employee.

other variables are not readily available at this time. Should further development of variables such as billet turnover and time in grade make a dynamic model more tractable, further research on the incidence of PCS costs might also be worthwhile. Without this information, the general overhead figure obtained from the entire Navy civilian population is as accurate as any.

Costs of Unemployment Benefits

The data sources used to estimate unemployment costs are the U.S. Department of Labor 66th Annual Report FY 1982 and Unemployment Insurance Statistics, Oct. - Dec. 1982.

The expected cost of unemployment is derived from general statistics on all individuals covered under the UCFE (Unemployment Compensation for Federal Employees) program. First, an unemployment rate was determined by dividing the total number of claims in 1982, C, by the total federal working population, P. To estimate an average cost per claim we computed the product of the average weekly benefit, B, the average weekly duration, D, and the unemployment rate, C/P.

$$(4.18) \text{ Unemployment Cost} = BDC/P .$$

This yields the expected yearly cost of unemployment for a federal employee.

Discussion

Unlike the payment of injury benefits (FECA) there is no budgetary transfer from the Navy to the Department of Labor (DOL) to

account for these costs. Furthermore, the current aggregate data kept by the DOL do not distinguish between Navy civilians and other claimants in the federal program.* Given the data available, therefore, a general overhead figure obtained from the entire federal employee population is a reasonably accurate estimate of expected unemployment cost.

Other Overhead Costs

There are a number of other budgeted items in the Manyear and Cost Report which have not been treated as specific cost elements in the model and are included as general overhead. The largest of these are overseas allowances for U.S. civilians working in foreign countries. Also included are the payment of benefits under special plans to non-citizens in foreign countries. Another fairly large outlay was made for Suggestion and Superior performance awards. Finally, a small amount was budgeted for uniform allowances for Navy civilians.

Discussion

It would be possible to remove all of these elements from the general overhead pool with varying amounts of research into the specific incidence of these costs. For example, it is probable that Suggestion and Superior performance awards are paid most frequently to higher level personnel in certain occupations with labor shortage

* Nor are data for the UCFE program broken down by other useful designators such as occupation or grade.

problems. It is not known at this point whether these data are available from the Compensation Group at OPM. Also, the payment of overseas allowances and non-citizen benefits is more applicable to billets in certain occupations and grades. A more specific allocation might be possible through a location analysis of the master file, with the assumption that the FOG/GS distribution remains stable over time.

4.11 DOWNTIME

The data sources for downtime are the Master and Training Files of the DMDC, Monterey and data from Manyear Cost Report, FY82 published by the Comptroller, Department of the Navy. In addition, price deflators for 1981-1983 were obtained from the Statistical Abstract of the United States, 1983.

The basis for downtime computations is a fictitious full-time work year of 2080 hours, corresponding to 52, 40-hour weeks. This value was chosen for its ubiquity as an industrial standard, both in the civil service and among civilian contractors supplying labor to the government. The adjective "fictitious" is used because virtually no one works this many hours during a normal year. There are several sources of downtime, or unworked but compensated time, which must be taken into account. These are:

- Holidays
- Vacations
- Sick Leave
- Administrative Leave
- Other earned leave
- Continuation pay
- Travel time
- Other non-productive time

Among these classes of downtime, only some are accurately tracked in the CBCM. Direct data are available on the first six elements. No data, however, have come to hand on time spent in travel or on such items as unauthorized absences which would be included in the residual category. One element in the residual category for which an estimate is made is time spent in filling vacancies and initiating a new billet. These are discussed under the heading of Recruiting Costs in Section 4.8, above.

The computation of downtime costs is accomplished in the CBCM, rather than in the pre-processor as is done for most other cost elements. This is due to the fact that, to be evaluated properly, downtime must be costed at full billet cost. Since full billet cost is computed inside the model, downtime costs must be estimated after the preliminary computation. The adjustment is a simple one. Let X_{10} be adjusted full billet cost and $X'_{10} = X_{10} - \text{DTC}$ where DTC is downtime cost. Then,

$$(4.19) \quad X_{10} = X'_{10} 2080 / (2080 - \text{DT}) ,$$

where DT is the number of hours of downtime and the ratio in brackets is, therefore, the reciprocal of the ratio of worked time to hypothetical fulltime. This ratio provides an inflator for non-billet costs (excluding downtime) by taking an average cost per hour worked and multiplying it by the number of hours considered fulltime.

This approach produces an estimate of billet cost identical in concept to that used by civilian contractors in developing their

estimates of the cost of a manyear. In that regard, it is therefore strictly comparable.* An important advantage of this method is that it compensates for widely differing benefit policies both within and outside the civil service. Vacation time varies from firm to firm and tends to vary as a function of LOS in both sectors. The net effect of this formulation is to cause billet costs to increase as a function of LOS, age and even grade. Vacation time increases with LOS, sick time is related to age through the morbidity rate, and administrative leaves tend to be given more frequently to senior than to junior employees.

Other sources of downtime not treated in this cost account, but dealt with in the CBCM are time in school (see Section 4.7) and time spent initiating a new billet or filling an existing billet (see Section 4.8). While the first are costs internal to the billet the second are costs allocated to the billet but incurred by another billet.

The computation of the number of downtime hours by each GS/FOG cell (DT) was carried out in three steps. First, depending on the LOS in a cell, predicted hours of annual leave were estimated according to the rules governing leave:

* There is one relatively unimportant exception. Many contractors, in making proposals to the government, make representations as to the average number of uncompensated overtime hours worked by salaried employees (i.e., employees exempt from the Fair Labor Standards Act). It is not known how much impact these representations have on the procurement authorities' decisions, but one expects little. This is appropriate for two reasons. First, delivery of extra hours is not an act to which the contractor can be bound and second, one expects that roughly similar uncompensated overtime is worked by civil servants as well. Thus, the matter can be ignored without influencing comparability of estimates.

$$\text{annual leave} = \begin{cases} 104 & \text{if } \text{LOS} < 3 \\ 160 & \text{if } 3 \leq \text{LOS} < 15 \\ 208 & \text{if } 15 \leq \text{LOS} \end{cases}$$

Second, every cell was allocated 72 hours of regular holiday downtime.* Third, the sum of all hours used in administrative, other earned leave, sick leave and continuation pay was distributed over all civilian employees of the Navy in the manner of an overhead number. For example, the average number of residual downhours per employee in 1982 was:

$$\begin{aligned} \text{downhours, other causes} &= 29,292,608 \text{ hours} / 282,114 \text{ employees} \\ &= 104.95 \text{ hours/employee} \end{aligned}$$

Therefore, from the two sources not dependent on LOS, total downhours are, 180.95 per year. Adding annual leave for LOS in the three ranges, the total hours are 281, 337 and 385 hours. As deductions from nominal 2080 hour-years, these represent billet cost increases of 15.6, 19.3 and 22.7 percent, respectively.

* This introduces a double count for employees who worked on holidays and were paid holiday premium rates.

5.0 BCM SYSTEM DATA SOURCES

5.1 UPDATING EBCM DATA SOURCES

Data inputs may be classified as tape files or Navy budgets. The EBCM contains tape handlers to process and update the data from each tape source. The new budget values must of course be entered by hand; there is an interactive routine to make this process as easy and simple as possible.

In this section we list sources for both the tapes and the budgets. With tape sources are sample request letters and tape format descriptions. It is vital that tape data conform to the format specifications, or else the tape processor programs will not work.

5.1.1 JUMPS

The following two pages contain a file format description of the JUMPS file extract required to update the EBCM data sets and a sample request letter. Send copies of these three pages to the address on the cover letter.

Date

T. J. Halloran, Director
Planning and Resources
Management Department
Navy Finance Center
1240 East 9th Street
Cleveland, Ohio 44199

Reference: Updating the Enlisted Billet Cost Model

Dear Mr. Halloran:

Enclosed is a file format description of a data extract that was prepared for The Assessment Group in FY83. The extract contained personnel pay records for both the commissioned and enlisted Navy for the month of October 1982. It was used to create a data set for the Enlisted Billet Cost Model.

Please provide us with the most recent October JUMPS extract to update this EBCM data set. It is vital that an identical format be used and that the data be written to a 9 track tape at 1600 bpi, blocked at a maximum of 8000 bytes per block, with an introductory label--as before. We are enclosing a copy of the tape layout you supplied The Assessment Group at that time.

Sincerely,

ASSESSMENT GROUP EXTRACT - Record

The following Tape Layout describes a record on the Assessment Group Extract Tape. All dates are in YYMMDD format. Packed decimal fields are right justified with sign in the rightmost position. Fields described as Filler are blank. The file is in ascending order of the last two digits of SSN.

<u>RECORD POSITION</u>	<u>SIZE/ MODE</u>	<u>DESCRIPTION/ CONTENTS</u>
1-9	9C-N	SSN
10	1C-AN	Filler
11-12	2C-AN	Pay Grade
13	1C-AN	Filler
14-18	5C-AN	Rating (enlisted)
19	1C-AN	Filler
20-24	5C-AN	UIC assigned
25	1C-AN	Filler
26-29	6P-N	Length of Service - PEBD
30	1C-AN	Filler
31-34	6P-N	Length of Service - ADBD
35	1C-AN	Filler
36-39	6P-N	Time Remaining on Contract - ENL TRC
40	1C-AN	Filler
41-44	6P-N	ACIP counter - ASER
45	1C-AN	Filler
46-49	6P-N	ACIP counter - ACD

<u>RECORD POSITION</u>	<u>SIZE/ MODE</u>	<u>DESCRIPTION/ CONTENTS</u>
50	1C-AN	Filler
51-52	3P-N	ACIP counter - MOF
53	1C-AN	Filler
54-57	6P-N	CSP Counter
58	1C-AN	Filler
59-62	6P-N	CSP Counter Date
63	1C-AN	Filler
64-65	3P-N	Occurs Count
66	1C-AN	Filler
67-241	The following series of Pay Code and amount occur up to 25 times:	
	3C-AN	Pay - Code
	7P-N	Amount

5.1.2 FAST

A standard output tape is obtained from the force structure model, FAST. It may be obtained from LT. Paul Von Hene, 202/694-5407. This standard output file is the 7 year projection output containing the 8 by 32 inventory FAST matrices. It must be obtained on a 9 track tape recorded at 1600 bpi.

5.1.3 DMDC

From the Defense Manpower Data Center two files are required. The Navy Enlisted DOD Individual Master and Loss/Edit files, End of Fiscal Year, are both required in order to calculate survivor rates for the model. If survivor rates have not altered significantly there is no need to update these.

Date

Michael Dove, Chief
Reports Branch
Defense Manpower Data Center
550 Camino El Estero, Suite 200
Monterey, California 93940

Reference: Updating the Enlisted Billet Cost Model

Dear Mr. Dove:

Enclosed is a file format description of data extracts from the Navy Enlisted DODI Master and Loss/Edit files, End of FY82, prepared for The Assessment Group in FY83. They were used to create a data set for the Enlisted Billet Cost Model.

Please provide us with the most recent End of Fiscal Year versions of these files to update EBCM data sets. It is vital that an identical format be used and that the data be written to a 9 track tape at 1600 bpi, blocked at a maximum of 8000 bytes per block, with no introductory label. We are enclosing a copy of the tape layout you supplied The Assessment Group at that time.

Sincerely,

NAVY OFFICER AND ENLISTED DODI MASTER AND LOSS EDIT FILE FORMAT

9 track, 1600 BPI
Record Length 67
Block Length less than 8000
Characters represented in EBCDIC

Name	Start Position	Length	Data Type
Social Security Number	1	4	B
Total Active Fed. Military Service	5	2	B
DoD Primary Occupational Group	7	2	B
DoD Secondary Occupational Group	9	2	B
Highest Year of Education	11	1	B
Pay Grade	12	1	B
Date of Birth	13	3	B
Marital Status	16	1	B
Number of Dependents	17	1	B
Sex	18	1	B
Educ Men Cats (ENL)/(OFF)	19	1	B
Mental Category (ENL)	20	1	B
Age at Entry	21	1	B
Age at Sep (LOSS)/Current Age (MAST)	22	1	B
RATE	23	3	C
NEC/Designator	27	3	C
Separation Program Designator	30	3	C
Interservice Separation Code	33	1	B
Date of Separation/Soft ETS	34	3	B
Basic Active Service Date	37	3	B
ETS Date	40	2	B
Date of Current Paygrade	42	2	B
Date of Latest Enlistment, etc.	44	2	B
Service Component	46	1	B
Year of Active Duty Service	47	1	B
Time in Grade	48	1	B
OESC	49	1	B
SRB multiplier	50	1	B
Reenlistment Eligibility	51	1	C
Pay Entry Base Date	52	3	B
UIC	55	6	C
Duty Rate/NEC	61	7	C

5.1.4 NITRAS

Required only if the training cost elements are to be updated. Its companion tape is the PCC tape (see below). In order to affix ratings to trained personnel the two most recent fiscal year files are required. These files contain records of completed training, where the year index of the record, the first field, indicates the fiscal year (1 or 2) they arrived to be trained. Both files (perhaps five tapes) are to be processed together.

Date

Don Niedert, MIISA
Naval Education and Training
Saufley Field,
Pensacola, Florida 32509

Reference: Updating the Enlisted Billet Cost Model

Dear Mr. Niedert:

Enclosed is a file format description of a data extract from the NITRAS SMF merged with data from the NAVM file prepared for The Assessment Group in FY83. It was used to create a data set for the Enlisted Billet Cost Model.

The extract contained SMF records--some fields merged into the extract from the then current NAVM. SMF records were requested if the date of admission to a training activity was either in FY81 or FY82. (Both Pass and Fail records were requested.) This entailed extracting data from the active, inactive and history SMFs.

Please provide us with another set of extracts--for the most recent two fiscal years--from the SMF files to update this EBCM data set. It is vital that an identical format be used and that the data be written to a 9 track tape at 1600 bpi, blocked at a maximum of 8000 bytes per block, with no introductory label--as before. We are enclosing a copy of the Tape Layout you supplied The Assessment Group at that time. Note that the first field, "Record ID" was 1 for the first year (FY81) and 2 for the second year (FY82). Please follow the same convention again. Thank you.

Sincerely,

NITRAS DATA EXTRACT REQUEST FORMAT SHEET

System: NITRAS

Application: SMF / NAVM

9 track, recorded at 1600 BPI, block factor less than 8000, in ASCII

Record Positions	Data Name	Size	Class	Value/Comments
1	Record ID	1	A	1=FY81, 2=FY82
2-3	FY	2	N	Sort Major
4	Type-Course	1	A/N	Sort Int. 1
5	SOC	1	A	Sort Int. 2
6-11	CLUEG*	6	A/N	Sort Int. 3
12-16	STU-UIC	5	A/N	Sort Int. 4
17-32	Short Activity Name	16	A/N	
33-36	RMS Cost Code	4	A/N	Sort Int. 5
37-40	CDP	4	A/N	Sort Int. 6
41-48	CIN	8	A/N	
49-57	SSN	9	A/N	Sort Int. 7
58-60	SAC	3	A/N	
61-65	Rank/Rate (SMF)	5	A/N	
66-70	Rank/Rate (NAVM)	5	A/N	
71-72	Pay Grade (SMF)	2	A/N	
73-74	Pay Grade (NAVM)	2	A/N	
75-78	ADSD	4	N	YYMM
79	SEX	1	A/N	
80-84	Date Arrived	5	N	Julian
85-90	Date Arrived	6	N	Gregorian
91-95	Date Enrolled	5	N	Julian
96-100	Date Grad/Attr	5	N	Julian
101-105	Date Transferred	5	N	Julian

* CLUEG is a field created from two others for the purpose of sorting. The first 4 characters are extracted from the NAVM file, the 4 digit rate code for enlistees (e.g., 6700 for Aviation Boatswain's Mates), or the 4 digit designator for officers. The last two characters are the paygrade as recorded on the NITRAS SMF: e.g., E5 or O3, etc.

5.1.5 PCC

The Per Capita Cost to train data base contains RMS reported budgets expended in the previous fiscal year--and some other costs, mainly for personnel--in such a way that the annual costs, costs per student-month or costs per graduate may be calculated for each course of Navy training. If the training billet costs are to be updated this file must be obtained.

Date

Jack Heyl, Assistant Chief of Staff
Chief of Naval Education and Training
Naval Air Station, Bldg 624
Pensacola, Florida 32508

Reference: Updating the Enlisted Billet Cost Model

Dear Mr. Heyl:

Enclosed is a file format description of the Per Capita Cost to train data base maintained at your facility. The data base was used as data input to the Enlisted Billet Cost Model in 1983 to evaluate the cost of training.

Please provide us with the current version of this same data base, to update the EBCM training costs. It is vital that an identical format be used and that the data be written to a 9 track tape at 1600 BPI as before. We are enclosing a copy of the tape layout you supplied The Assessment Group at that time.

Sincerely,

PCC TO TRAIN DATA REQUEST FILE FORMAT SHEET

Per Capita Tape Record Layout

2/11/83

9 track, 1600 BPI

Record Length, Block Length = 1080 Characters

Code - EBCDIC

Field No.	Start Position	End Position	Length	Description	Type
1	1	6	6	Filler	A/N
2	7	11	5	OB UIC	A/N
3	12	15	4	Cost Code	A/N
4	16	17	2	SF Code	A/N
5	18	24	7	Dist Code	A/N
6	25	46	22	Acitivity Name	A/N
7	47	57	11	Course Title	A/N
8	58	64	6	Course Type	A/N
9	64	64	1	Command Code	A/N
10	65	68	4	Type School	A/N
11	69	76	8	Work Units	A/N
12	77	83	7	Dir Mil Hrs	A/N
13	84	90	7	Dir Civ Hrs	A/N
14	91	98	8	Dir Mil Lab	A/N
15	99	106	8	Dir Civ Lab	A/N
16	107	113	7	Dir Supplies	A/N
17	114	120	7	Dir Contract	A/N
18	121	127	7	Dir Misc	A/N
19	128	134	7	Acty Fac Mil Hrs	A/N
20	135	141	7	Acty Fac Civ Hrs	A/N
21	142	149	8	Acty Fac Mil Lab	A/N
22	150	157	8	Acty Fac Civ Lab	A/N
23	158	164	7	Acty Fac Supplies	A/N
24	165	171	7	Acty Fac Contract	A/N
25	172	178	7	Acty Fac Misc	A/N
26	179	192	14	Filler	A/N
27	193	200	8	Host Mil Lab	A/N
28	201	222	22	Filler	A/N
29	223	230	8	Host Misc	A/N
30	231	240	10	Filler	A/N
31	244	251	8	Other Activity Mil Lab	A/N
32	252	273	12	Filler	A/N
33	274	280	7	Other Acty Misc	A/N
34	281	294	14	Filler	A/N
35	295	302	8	ADP Mil Lab	A/N
36	303	324	22	Filler	A/N
37	325	331	7	ADP Misc	A/N
38	332	345	14	Filler	A/N
39	346	353	8	CNET Mil Lab	A/N
40	354	360	7	Filler	A/N

Field No.	Start Position	End Position	Length	Description	Type
41	361	375	15	Filler	A/N
42	376	382	7	CNET Misc	A/N
43	383	396	14	Filler	A/N
44	397	404	8	Funct Mil Lab	A/N
45	405	412	8	Funct Civ Lab	A/N
46	413	419	7	Funct Supplies	A/N
47	420	426	7	Funct Contract	A/N
48	427	433	7	Funct Misc	A/N
49	434	447	14	Filler	A/N
50	448	455	8	STAFF Med Mil Lab	A/N
51	456	477	22	Filler	A/N
52	478	480	3	STAFF Med Misc	A/N
53	481	484	4	STAFF Med Misc	A/N
54	485	528	44	Filler	A/N
55	529	535	7	STAFF FAM Housing	A/N
56	536	549	14	Filler	A/N
57	550	557	8	STAFF PCS	A/N
58	558	600	43	Filler	A/N
59	601	630	30	Filler	A/N
60	631	637	7	TRNG EQP MT	A/N
61	638	681	44	Filler	A/N
62	682	688	7	MAJ Projects	A/N
63	689	720	32	Filler	A/N
64	721	732	12	Filler	A/N
65	733	739	7	EQP DEPR	A/N
66	740	783	44	Filler	A/N
67	784	790	7	BLDG DEPR	A/N
68	791	804	14	Filler	A/N
69	805	815	8	Stu Med MP/N	A/N
70	813	834	22	Filler	A/N
71	835	840	6	Stu Med Misc	A/N
72	841	841	1	Stu Med Misc	A/N
73	842	885	44	Filler	A/N
74	886	892	7	Stu Family Housing	A/N
75	893	936	44	Filler	A/N
76	937	943	7	Stu TAD	A/N
77	944	957	14	Filler	A/N
78	958	965	8	Stu PCS	A/N
79	916	1008	40	Filler	A/N
80	1009	1016	8	Stu Salary	A/N
81	1017	1045	29	Filler	A/N
82	1046	1052	7	Attrite Weeks	A/N
83	1053	1059	7	Grads	A/N
84	1060	1065	6	Curriculum Length	A/N
85	1066	1071	6	Attrites	A/N
86	1072	1080	9	Filler	A/N

5.1.6 VALUES UPDATED BY HAND

The following descriptions of model parameters and budget values will help in the task of their updating. They are grouped into two lists to reflect their display as such in the model. Sources for updating Navy budgets are also listed.

A. PARAMETERS

At various places in the EBCM model parameters are offered to the user for his review. Some may be altered with proper consideration.

a) Number of ratings (105).

This may not be updated without adjusting for a new value throughout the data file preparation and all companion procedures. This will entail a recompilation and linking effort.

b) FICA tax rate (percent)--update.

The present value of 6.7 represents the percentage of wages, up to a maximum, that employers must pay the IRS.

c) FICA cap (dollars max)--update.

The maximum wage on which FICA tax is due.

d) BAS (dollars daily)--update.

The cost to the Navy of supplying subsistence (in kind) at their enlisted dining facilities. An all Navy average is computed from the MP-N (Military Personnel-Navy) annual budget report to congress.

- e) No. of days lost on holidays, leave.

The addition of authorised yearly leave and the ten national holidays.

- f) No. of T.P.P. man-years lost--update.

Total Manyears lost due to Transients, Patients and Prisoners is reported in the MP-N Budget Report. This figure is then converted to the average number of days of service lost via TPP per person.

- g) Billet hours delivered at sea.

The number of manhours that make up a work manyear at sea. Take the average length of a sea work day and multiply by the number of work days in a year. The current figure, based on 70 hour week is 3,640 manhours.

- h) Billet hours delivered on shore.

The number of manhours that make up a manyear of shore duty, which is assumed to be 2,080 using a forty hour week.

- i) Civilian hours worked per year.

The number of manhours that make up a civilian work manyear. The standard figure, which civilian contractors use, and which should not be changed, is 2,080.

B. BUDGET VALUES

Several annual budget totals are required at various places in the model. However they are updated together in one routine. Most of these values may be updated from the (MP-N) Military Personnel-Navy, Annual Budget Report to congress.

a) Budget: Recruitment.

Consult the Recruiting Resource Report, FY83 President's Budget Request, information from which may be obtained from the Recruit Command, 202/696-4197. Enlistment bonuses are entered separately so do not include them here.

b) Budget: Accession Clothing, initial.

Take the figure for initial clothing (currently \$446.18) and multiply by the number of initial contracts, a number available from the Recruit Command (q.v., a).

c) Budget: Unemployment benefits.

From the Monthly Labor Review obtain the figure for total unemployment benefits paid to ex-service members. Multiply by the proportion of the armed forces that are in the enlisted Navy.

d) Budget: Commissary.

From the O&M-N budget report. Our source for this item was CDR Ross Hendricks, AA G804, 202/695-3415, who made available to us the Operating and Manpower-Navy budget for FY82 commissaries. This figure was inflated to FY83 dollars and the enlisted service proportion was assigned to this element.

e) Budget: CHAMPUS.

From the CHAMPUS budget report combine medical and administrative costs. Our source has been Comptroller, Mr. J. Radcliffe, 202/254-4075.

- f) Budget: Prisoner Apprehension.
Consult the MP-N budget report.
- g) Budget: PCS- Accession.
Consult the MP-N budget report.
- h) Budget: PCS- Training.
Consult the MP-N budget report.
- i) Budget: PCS- Operational.
Consult the MP-N budget report.
- j) Budget: PCS- Rotational.
Consult the MP-N budget report.
- k) Budget: PCS- Separation.
Consult the MP-N budget report.
- l) Budget: PCS- Organized Units.
Consult the MP-N budget report.
- m) Budget: Enlistment Bonuses.
Consult the MP-N budget report.
- n) Budget: Separation Payments.
Consult the MP-N budget report.

5.2 UPDATING OBCM DATA SOURCES

Data inputs may be classified as tape files or Navy budgets. The OBCM contains tape handlers to process and update the data from each tape source. The new budget values must of course be entered by hand; there is an interactive routine to make this process as easy and simple as possible.

In this section we list sources for both the tapes and the budgets. With tape sources are sample request letters and tape format descriptions. It is vital that tape data conform to the format specifications, or else the tape processor programs will not work.

5.2.1 JUMPS

The following two pages contain a file format description of the JUMPS file extract required to update the OBCM data sets and a sample request letter. Send copies of these three pages to the address on the cover letter.

Date

T. J. Halloran, Director
Planning and Resources
Management Department
Navy Finance Center
1240 East 9th Street
Cleveland, Ohio 44199

Reference: Updating the Officer Billet Cost Model

Dear Mr. Halloran:

Enclosed is a file format description of a data extract that was prepared for The Assessment Group in FY83. The extract contained personnel pay records for both the commissioned and enlisted Navy for the month of October 1982. It was used to create a data set for the Officer Billet Cost Model.

Please provide us with the most recent October JUMPS extract to update this OBCM data set. It is vital that an identical format be used and that the data be written to a 9 track tape at 1600 bpi, blocked at a maximum of 8000 bytes per block, with an introductory label—as before. We are enclosing a copy of the tape layout you supplied The Assessment Group at that time.

Sincerely,

ASSESSMENT GROUP EXTRACT - Record

The following Tape Layout describes a record on the Assessment Group Extract Tape. All dates are in YYMMDD format. Packed decimal fields are right justified with sign in the rightmost position. Fields described as Filler are blank. The file is in ascending order of the last two digits of SSN.

<u>RECORD POSITION</u>	<u>SIZE/ MODE</u>	<u>DESCRIPTION/ CONTENTS</u>
1-9	9C-N	SSN
10	1C-AN	Filler
11-12	2C-AN	Pay Grade
13	1C-AN	Filler
14-18	5C-AN	Designator (officer), Rating (enlisted)
19	1C-AN	Filler
20-24	5C-AN	UIC assigned
25	1C-AN	Filler
26-29	6P-N	Length of Service - PEBD
30	1C-AN	Filler
31-34	6P-N	Length of Service - ADBD
35	1C-AN	Filler
36-39	6P-N	Time Remaining on Contract - ENL TRC
40	1C-AN	Filler
41-44	6P-N	ACIP counter - ASER
45	1C-AN	Filler
46-49	6P-N	ACIP counter - ACD

<u>RECORD POSITION</u>	<u>SIZE/ MODE</u>	<u>DESCRIPTION/ CONTENTS</u>
50	1C-AN	Filler
51-52	3P-N	ACIP counter - MOF
53	1C-AN	Filler
54-57	6P-N	CSP Counter
58	1C-AN	Filler
59-62	6P-N	CSP Counter Date
63	1C-AN	Filler
64-65	3P-N	Occurs Count
66	1C-AN	Filler
67-241	The following series of Pay Code and amount occur up to 25 times:	
	3C-AN	Pay - Code
	7P-N	Amount

5.2.2 DMDC

From the Defense Manpower Data Center two files are required. The Navy Officer DOD Individual Master and Loss/Edit files, End of Fiscal Year, are both required in order to calculate inventories and survivor rates for the model.

Date

Michael Dove, Chief
Reports Branch
Defense Manpower Data Center
550 Camino El Estero, Suite 200
Monterey, California 93940

Reference: Updating the Officer Billet Cost Model

Dear Mr. Dove:

Enclosed is a file format description of data extracts from the Navy Officer DODI Master and Loss/Edit files, End of Fiscal Year, prepared for The Assessment Group in FY83. They were used to create a data set for the Officer Billet Cost Model.

Please provide us with the most recent End of Fiscal Year versions of these files to update OBCM data sets. It is vital that an identical format be used and that the data be written to a 9 track tape at 1600 BPI, blocked at a maximum of 8000 bytes per block, with no introductory label. We are enclosing a copy of the tape layout you supplied The Assessment Group at that time.

Sincerely,

NAVY OFFICER AND ENLISTED DODI MASTER AND LOSS EDIT FILE FORMAT

9 track, 1600 BPI
Record Length 67
Block Length less than 8000
Characters represented in EBCDIC

Name	Start Position	Length	Data Type
Social Security Number	1	4	B
Total Active Fed. Military Service	5	2	B
DoD Primary Occupational Group	7	2	B
DoD Secondary Occupational Group	9	2	B
Highest Year of Education	11	1	B
Pay Grade	12	1	B
Date of Birth	13	3	B
Marital Status	16	1	B
Number of Dependents	17	1	B
Sex	18	1	B
Educ Men Cats (ENL)/(OFF)	19	1	B
Mental Category (ENL)	20	1	B
Age at Entry	21	1	B
Age at Sep (LOSS)/Current Age (MAST)	22	1	B
RATE	23	3	C
NEC/Designator	27	3	C
Separation Program Designator	30	3	C
Interservice Separation Code	33	1	B
Date of Separation/Soft ETS	34	3	B
Basic Active Service Date	37	3	B
ETS Date	40	2	B
Date of Current Paygrade	42	2	B
Date of Latest Enlistment, etc.	44	2	B
Service Component	46	1	B
Year of Active Duty Service	47	1	B
Time in Grade	48	1	B
OESC	49	1	B
SRB multiplier	50	1	B
Reenlistment Eligibility	51	1	C
Pay Entry Base Date	52	3	B
UIC	55	6	C
Duty Rate/NEC	61	7	C

5.2.3 VALUES UPDATED BY HAND

The following descriptions of model parameters and budget values will help in the task of their updating in future years. They are grouped into two lists to reflect their display as such in the model. Sources for updating Navy budgets are also listed.

A. PARAMETERS

At various places in the OBCM model parameters are offered to the user for his review. Some of those whose descriptions follow may be altered after proper consideration.

a) Number of Designator Communities (21).

This may not be updated without adjusting for a new value throughout the data file preparation and all companion procedures. This will entail a recompilation and linking effort.

b) FICA tax rate (percent)--update.

The present value of 6.7 represents the percentage of wages, up to a maximum, that employers must pay the IRS.

c) FICA cap (dollars max)--update.

The maximum wage on which FICA tax is due.

d) No. of days lost on holidays, leave.

The addition of authorized yearly leave and the ten national holidays.

e) No. of T.P.P. man-years lost--update.

Total Manyears lost due to Transients, Patients and Prisoners is reported in the MP-N Budget Report. This figure is then converted to the average number of days of service lost via TPP per person.

f) Billet hours delivered at sea.

The number of manhours that make up a work manyear at sea. Take the average length of a sea work day and multiply by the number of work days in a year. The current figure, based on 70 hour week is 3,640 manhours.

g) Billet hours delivered on shore.

The number of manhours that make up a manyear of shore duty, which is assumed to be 2,080 using a forty hour week.

h) Civilian hours worked per year.

The number of manhours that make up a civilian work manyear. The standard figure, which civilian contractors use, and which should not be changed, is 2,080.

B. BUDGET VALUES

Several annual budget totals are required at various places in the model. However they are updated together in one routine. Most of these values may be updated from the MP-N, the Military Personnel-Navy, Annual Budget Report to congress.

a) Budget: Recruitment.

Consult the Recruiting Resource Report, FY83 President's Budget Request, information from which may be obtained from the Recruit Command, 202/696-4197.

b) Budget: Accession Clothing, initial.

Take the figure for initial clothing and multiply by the number of initial contracts, a number available from the Recruit Command.

c) Budget: Unemployment benefits.

From the Monthly Labor Review obtain the figure for total unemployment benefits paid to ex-service members. Multiply by the proportion of the armed forces that are in the commissioned Navy.

d) Budget: Commissary.

From the O&M-N budget report. Our source for this item was CDR Ross Hendricks, AA G804, 202/695-3415, who made available to us the Operating and Manpower-Navy budget for FY82 commissaries. This figure was inflated to FY83 dollars and the commissioned service proportion was assigned to this element.

e) Budget: CHAMPUS.

From the CHAMPUS budget report combine medical and administrative costs. Our source has been Comptroller, Mr. J. Radcliffe, 202/254-4075.

f) Budget: PCS- Accession.

Consult the MP-N budget report.

- g) Budget: PCS- Training.
Consult the MP-N budget report.
- h) Budget: PCS- Operational.
Consult the MP-N budget report.
- i) Budget: PCS- Rotational.
Consult the MP-N budget report.
- j) Budget: PCS- Separation.
Consult the MP-N budget report.
- k) Budget: PCS- Organized Units.
Consult the MP-N budget report.
- l) Budget: Separation Payments.
Consult the MP-N budget report.

5.3 UPDATING CBCM DATA SOURCES

To the extent possible, the CBCM data set has been constructed from annually updated information sources. The most important of these is the End of Fiscal Year Civilian Master File maintained by the Defense Manpower Data Center (DMDC), Monterey. The Master File is updated quarterly and the last tape for every year reflects all activity file changes during the preceding four quarters. The following letter and file format description may be used to request CBCM data inputs from DMDC.

Date

Michael Dove, Chief
Reports Branch
Defense Manpower Data Center
550 Camino El Estero, Suite 200
Monterey, California 93940

Reference: Updating the Civilian Billet Cost Model

Dear Mr. Dove:

Enclosed are file format descriptions of data extracts from the Navy Civilian DODI CPDF Edit Transaction, Master and Training files, End of FY82, prepared for The Assessment Group in FY83. They were used to create a data set for the Civilian Billet Cost Model.

Please provide us with the most recent End of Fiscal Year versions of these files to update CBCM data sets. It is vital that an identical format be used and that the data be written to a 9 track tape at 1600 BPI, blocked at a maximum of 8000 bytes per block, with no introductory label. We are enclosing a copy of the tape layout you supplied The Assessment Group at that time.

Sincerely,

NAVY CIVILIAN DODI CPDF MASTER EDIT & TRANSACTION FORMAT

9 track, 1600 BPI
Record Length 33
Block Length less than 8000
Characters represented in EBCDIC

<u>NAME</u>	<u>POSITIONS</u>	<u>LENGTH</u>	<u>DATA TYPE</u>
Social Security Number	1-4	4	B
Date of Birth	5-7	3	B
Work Schedule	8	1	B
Salary	9-13	5	C
Pay Basis	14	1	B
FEGLI	15	1	B
Retirement Code	16	1	B
Sex	17	1	B
Pay Plan	18	1	B
Grade	19	1	B
Step	20	1	B
Latest Naute of Action Codes	21-23	3	C
Total Federal Service Months	24-25	2	B
Total Federal Service Years	26	1	B
Age	27	1	B
MOG-FOG	28	1	B
Yearly Compensation	29-33	5	C

NAVY CIVILIAN DODI CPDF TRAINING FILE FORMAT

9 track, 1600 BPI
Record Length 297
Block Length less than 8000
Characters represented in EBCDIC

<u>NAME</u>	<u>POSITIONS</u>	<u>LENGTH</u>	<u>DATA TYPE</u>
Social Security Number	1	9	C
Direct - Cost	10	4	C
Indirect - Cost	14	4	C
On-Duty Hours	18	4	C
Off-Duty Hours	22	4	C

The last 4 fields are repeated 17 times and, for this format, will be referred to as Section 2 thru Section 18, each section containing the 4 data fields.

Section 2	26	16	C
Section 3	42	16	C
Section 4	58	16	C
Section 5	74	16	C
Section 6	90	16	C
Section 7	106	16	C
Section 8	122	16	C
Section 9	138	16	C
Section 10	154	16	C
Section 11	170	16	C
Section 12	186	16	C
Section 13	202	16	C
Section 14	218	16	C
Section 15	234	16	C
Section 16	250	16	C
Section 17	266	16	C
Section 18	282	16	C

Another regular data source is the Navy Comptroller's Office, chiefly for the annual Manyear and Cost Report. This report provides budget data for premium pays, injury benefits, overhead items and downtime elements. The compensation and benefit rules of the civil service are published regularly and in great detail in the Federal Employee's Almanac which becomes available around February of each year.

Certain statistics used in the CBCM are readily available from a variety of sources and represent no particular concern: price deflators are an example. The Department of Labor produces an annual Injury Report used in the computation of injury benefits. Various other data are published on a regular basis in Federal Fringe Benefit Facts (OPM), annual reports of the Department of Labor, and Unemployment Insurance Statistics, also from DOL. The most difficult cost element, both in computation and updating, is the retirement account. A large number of sources were used in the development of the retirement computation. These were developed into two large data files for computational purposes: the retirement file and the demographic file. The first contains basic data from the DMDC Master File broken down into the six basic retirement computation units (RCU's) for each FOG/GS cell. The RCU's are groupings of the members of a FOG/GS cell by sex and three LOS categories: 0-5, 5-12 and 12 and over. These groups were determined on the basis of the form in which certain retirement data are available. The basic data contained in the retirement file are mean

age, LOS and wage as well as unit count by RCU. This portion of the retirement computation presents no problem in updating.

The demographic file can be thought of as consisting of two kinds of data: those which change rapidly and those which change slowly. The former must be updated on an annual basis, while the latter can be updated as new data become available.

Annually updated data in the demographic file are the various series of age specific separation rates: withdrawal, death and disability. In addition, life table values for civil servants including expectation of life at specific ages for specific populations (disabled, annuitants, employees and various groups of survivors) must be updated continually. All these rates are available on a continuing basis in the annual reports of the Board of Actuaries of the Civil Service Retirement System. They do not, however, stay closely up to date. The most recent rates, for example, were published in the 1975 Annual Report and based on a census of civil service employees conducted in 1972. Some of the data are from as far back as 1970. While not undertaken in the present study, these rates could be updated roughly by comparison with changes in nationwide rates which are reported on a year-to-year basis. The procedure is arduous, however, and since age specific demographic characteristics tend to change very slowly, the benefits of doing so would be rather small.

Other elements in the demographic file are even more out-of-date. The most important of these is the probability of cashout,

given withdrawal from the civil service, by age and LOS. The data in use are from a 1967 10% sample survey whose accuracy is questionable. We know of no plans to update or replace the survey at this time, however.

The following is a list of data sources for the calculation of each billet cost element. Not all data sources need to be refreshed yearly. The most important for updating are the DMDC Master Civilian file and the Department of the Navy, Manyear and Cost Report.

Base Pay

- 1) Navy Civilian Master File, FY 1982 - Defense Manpower Data Center (DMDC), Mike Dove, 550 Camino El Estero, Suite 200, Monterey, California, 93940. Ph. 408/375-4131.

Premium Pay

- 1) Department of Navy, Manyear and Cost Report, FY 1982. For specific budget data on premium pay expenditures for GS and wage board personnel.
- 2) Payroll analysis - authorized and directed by Rod Vessels, Comptroller's office, Rm. 202, Bldg. 300, Long Beach Naval Shipyard. Ph. 213/547-8377. Data on incidence of overtime by grade, pay plan for wage board and GS personnel.
- 3) Payroll analysis - authorized and directed by Marian Flanagan (for Naval Air Rework Facility, North Island) - Navy Finance Center, Foot of Broadway, San Diego, Calif. Data on overtime incidence for personnel working in the NARF.
- 4) Federal Employees' Almanac, 1983 - general information on qualifications and restrictions for premium payments.

Retirement

- 1) "Board of Actuaries of the Civil Service Retirement System Fifty-Second Annual Report," House Document No. 94-203, Washinton, D.C., USGPO, 1975. Source, for yield on CSRS investments and interest paid on employee contributions.

- 2) Federal Fringe Benefit Facts, 1979, U.S. Civil Service Commission, Washington, D.C., 1980. For data on the requirements and actuarial formulas of the Civil Service Retirement System. Also, CSRS trend tables.
- 3) Federal Employees' Almanac, 1983 - Source for determining and computing employee contribution, eligibility requirements for different annuities, and the size of annuities.
- 4) "Fiftieth Annual Report of the Board of Actuaries of the Civil Service Retirement System," House Document No. 93-37, Washington, D.C., USGPO, 1973. Contains tables on probabilities of certain events occurring to employees of given LOS, age, and sex.
- 5) "Refund Study," unpublished manuscript, Office of the Actuary, OPM. 1968. For data on the probability of cashing out of retirement system given age, LOS characteristics.
- 6) Statistical Abstract of the United States, 1982, Department of Commerce, Washington, D.C., USGPO, 1982. Contains demographic tables used to determine probable marital and family status of employees.
- 7) Civilian Master File, FY 1982 - For FOG/GS cell data on age, LOS, and Salary distributions.
- 8) Laws Relating to Civil Service Retirement, G. Udell, USGPO, Washington, D.C., 1976. General source for all information on the mechanics of the Civil Service Retirement system.

Life Insurance (FEGLI)

- 1) Federal Employees' Almanac, 1983 - Joseph Young, editor, Federal Employees' News Digest, Inc., P.O. Box 457, Merrifield, Virginia, 22116. Ph. 703/533-3031. Contains insurance tables, premium rates.
- 2) Master File, FY 1982 - DMDC. Used for estimating the within cell probability of taking life insurance.

Training

- 1) Civilian Training File, FY 1980 - from DMDC with approval from Ben Collins, Rm. 6439, Office of Personnel Management, 1900 E Street, N.W., Washington, D.C., 20415. Ph. 202/632-490. Data on hours of training, tuition, and travel costs.

- 2) Civilian Master Files, FY 1980 and FY 1982 - DMDC. For data on FOG's of trained employees, employee salaries, and population counts.
- 3) National Economic Trends, Federal Reserve Bank of St. Louis, July 31, 1982 - GNP deflators used in updating 1980 cost data.

Recruitment

- 1) Margi Murtaugh, Recruitment Division, Rm. 6546, Office of Personnel Management. Ph. 202/632-6040. Budget data used to develop overhead component of recruitment cost.
- 2) Doris Chacon, Employment Office, NPRDC. Ph. 619/294-4567. Informal data on downtime element of recruitment including interviewing, evaluation, position description writing, etc.
- 3) Ed Powojski, Long Beach Naval Shipyard, Code 140, Rm. 551, Bldg. 300. Ph. 213/547-7323. Data on recruitment of LBNS general schedule personnel.
- 4) Perry Gilchrist, Long Beach Naval Shipyard, Code 170.1, employment Division, Personnel Staffing Specialist. Ph. 213/547-8275. Data on recruitment procedures and costs of wage board and general schedule personnel.

Injury Benefits

- 1) Navy CY '79 Injury Reports, by Cause/Occupation, Donald L. Kress, Rm. C4325, Department of Labor (NDOL). Ph. 202/523-7871. Records of injury incidence by occupation.
- 2) Department of Navy, Manyear and Cost Report, FY 1982, Bob Lee, Office of the Comptroller, Rm. 606, Financial Control Division, NCB-3, Crystal Mall #2, Washington, D.C., 20376. Ph. 202/697-7819. Budget outlays for FECA (to the Department of Labor) to pay for injury benefits.
- 3) Civilian Master File, FY 1982 - DMDC. For cell population sizes to generate average injury benefits.

Overhead Costs

Health Insurance

- 1) Federal Fringe Benefit Facts 1982, - Tables D-8, D-9. Used in computing weighted average health insurance premiums.
- 2) Federal Employees' Almanac, 1983 - Data on rules governing employee/federal contributions to premium payments.

Severance Pay, PCS Costs

- 1) Department of Navy, Manyear and Cost Report FY 1982 - (Exhibit B-1). For budget amounts used in generating overhead constraints.
- 2) Civilian Master File, FY 1982 - Employee population counts.

Unemployment Costs

- 1) U.S. Department of Labor, 66th Annual Report, FY 1979, (p. 148) - Source for data on average length of benefit period and benefit amount.
- 2) Unemployment Insurance Statistics - U.S. Department of Labor, Employment and Training Administration, October-December 1982. Data for generating unemployment rate for federal employees under UCFE program.

Other Overhead Costs

- 1) Department of Navy, Manyear and Cost Report, FY 1982 - Exhibit B-1). Budget figures on payments to foreign employees, overseas benefits, uniform allowances, and superior performance awards.
- 2) Civilian Master File, FY 1982 - Employee population counts.

Downtime Costs

- 1) Federal Employees Almanac, 1983 - Source for rules on annual, sick and other leave components.
- 2) Department of Navy, Manyear and Cost Report, FY 1982 - (Exhibit D-1). Total incidence of leave for civilians.*

* See recruitment, training sections for downtime associated with those elements.

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