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Research Memorandum 69-2

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CONVERSION OF THE RAC 10-YEAR MODEL
FOR USE ON THE CDC-3300 COMPUTER

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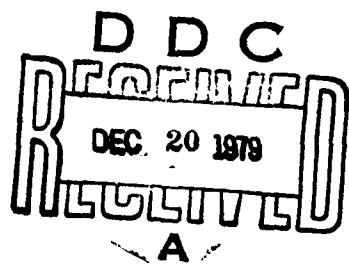
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CONVERSION OF THE RAC 10-YEAR MODEL FOR USE
ON THE CDC-3300 COMPUTER

The Research Analysis Corporation, McLean, Virginia, in 1967 produced a model and a computer program implementing the model on the IBM 7040 [1] for the Department of the Army to assist the Deputy Chief of Staff for Personnel in evaluating policies related to the procurement, promotion, and retention of commissioned officers. Model and computer program implementing the model were produced under contract No. DA 44-188-ARO-1. Documentation of the computer program is contained in User's Guide to a Computer Model for Projecting the Impact of Officer Procurement, Promotion, and Retention Policies by Leon W. Transeau, RAC Technical Paper 286, December 1967. The Guide is needed for use of the program and for reference in reading the present Research Memorandum.

BESRL was asked by DCSPER for assistance in converting the program for use on the CDC-3300 [1] (a computer possessed by AIDSCOM, DATCOM, and BESRL) and to provide technical assistance to the DATCOM personnel who had responsibility for running the program on an operational basis. The provision of this assistance fell within the mission of subtask b of SIMPO-I. This Memorandum is in the nature of a supplement describing and discussing the converted program provided by BESRL.

The BESRL computer could not handle such a large program nor could it then compile the one-way logical IF statements used by the RAC programmers. In converting the program it was necessary to organize it into a main program with ten overlays, and the one-way statements had to be rewritten as two-way IF statements. A small program had to be written to transfer the Officer Master Tape Record onto a disk since the BESRL computer did not have tape drives at that time.

COL O. Metheny, CPT A. Patz, and CPT W. DeVaughan of ODCSPER-DPSR-SDY, CPT R. Kilinski of ODCSPER-DMPP-P&S, and CPT P. Ryan of ODCSPER-DPD-CAD have provided data for running the program and have, through their experience in attempting to interpret results obtained on the BESRL computer, helped pinpoint reasons for difficulty in its use.

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[1] Commercial designations are included as essential to the conversion described. Their use does not constitute indorsement by the Behavioral Science Research Laboratory or by the Army.

In response to a request from CPT Ryan to introduce quarterly (rather than annual) rates into the model for the purpose of evaluating various phasedown policies, a major revision of the RAC 10-year model has been designed and programmed in BESRL. The capability of the model was extended in several other ways as a result of suggestions from these officers. The testing and documentation of the revised model, to be called the BESRL X80 Procurement, Promotion, and Retention Model, will be accomplished as a SIMPO-II product.

Another purpose of the Memorandum is to report BESRL experience with the RAC model and to invite suggestions for additional features that may be incorporated into the SIMPO-II model before it is released. A description of the converted RAC program's organization into overlays, further direction in preparing the numerous data cards required (to avoid difficulties experienced in the past), and reasons for variations in the projection print-outs will be followed by a brief description of the changes, shortcuts, and new features presently planned but subject to further modification.

ORGANIZATION OF CONVERTED PROGRAM INTO OVERLAYS

The main program calls the ten overlays and contains eight subroutines that are used by more than one overlay. They are: CLEAR, WAIT, EQ, ERRWRT, TOTAL, EDIT3, EDIT9, and CHNGID. Overlay 1 is called only the first simulated year and processes the Type 1-5 Data Cards. Overlay 2 is called for each simulated year of projection and processes Type 6-13 Data Cards. All other overlays are called each year and consist of the following subroutines:

OVERLAY	SUBROUTINES
3	REQMNT, ATTRT, ZERO, MADD, MSUBT, MMULT, MSUMC
4	MANDSP, SEPP, EDIT6
5	SUBTOT, MAGCAL, MAGE, VACADJ, HIRNK
6	PROZON, AUTOPR, PROMOT
7	RATEST, TRANS, XFR, AGE, PROCUG
8	AVYIGD, EDIT8
9	EDIT5
10	EDIT1, EDIT2, EDIT4, EDIT7

The program used over 21,000 locations for the variables that had to be held in COMMON for use by several overlays; in a computer with only 32,000 locations, the overlays therefore had to be rather short. An early run took 35 minutes and used 90 data cards for the first year of projection, 100 for the second year, and approximately 10 each for years 3-10. The run time would have been slightly increased if there had been more change cards for years 3-10. Much of the time was used in printing the 96 pages of tables normally output for a 10-year projection.

DIFFICULTIES ENCOUNTERED IN PREPARING DATA CARDS

A considerable part of the difficulty BESRL and several users had in checking and in preparing data cards of the 13 types required by the program can be attributed to differences between what the User's Guide says is needed and what the program coding actually calls for. Some examples follow.

TYPE 2 DATA CARD: MISCELLANEOUS CODES

The format specified on page 33 of the Guide does not agree with the format by which the card is read into the computer (lines 007600-007800 on page 107). The program is asking for 11 fields instead of 10 and requires Field 9 to be a variable called IBOLT which is not described until page 131. IBOLT is a code to indicate whether RA officers who were considered, but not selected, for temporary promotion should be placed in the Passover 1 category (IBOLT=1) or whether they should remain in their present time-in-grade categories (IBOLT=0). The program calls for Field 11 to be a variable called IMAST which is not explicitly described but is what the Field 9 definition on page 32 was intended to describe. The program needs a zero code in column 52 of the Type 2 card to read the inventories from tape or disk in the format 1000 (page 92 of Summary Program) or a non-zero code to read them with format 1001 (line 009700).

> NOTE: The model has over 2900 lines of coding that are numbered 001000 through 299300 at the right side of pages 106-154 of the Guide. These are the line numbers referred to in the present Memorandum.

THE SENTINEL CARD

The sentinel card when punched as described on page 28 (all 9s in columns 1-80) causes a computer diagnostic after the Type 4 Data Card. The computer reads Field 9 (columns 60-66) as 9999999 when it hits the sentinel card. This exceeds the $2^{23}-1$ limit for reading integer format. Leaving column 60 blank is a solution, but since the program does not look for 9s beyond column 28 on any of the cards, it is simpler to have all sentinel cards punched 9 in columns 1-28 only.

TYPE 6 DATA CARD: PROCUREMENT LEVELS

It is implied on line 4 of page 39 that procurement can be made to all six grades, but the accomplishment of this function in the program is restricted to CPT, 1LT, and 2LT (lines 015300-015700).

According to page 37, a separate Type 6 data card is required for each year of projection. Actually, a card for each of the three grades is required with the priorities punched even though the numbers to be procured are zero (lines 221000-228100).

TYPE 8 DATA CARD: TEMPORARY-PROMOTION RATES

The sentence on page 39 (line 5 from bottom) saying that promotions for the grade of colonel are automatic and at the rate of 100 percent is obviously in error and should be deleted.

It is not explicitly stated that the grades of LTC through 2LT may have a maximum of only one Type 8 card each year, nor that if a zone promotion is ever to be used for a given grade a Type 3 data card showing the cutoff date to be used the first time (regardless of the year in which it will be used) must be read in with the first year's data cards.

The codes possible for Field 5 on page 41 are 1 to 13, not 1 to 31.

TYPE 9 DATA CARD: MANDATORY-SEPARATION RATES

Line 4 of page 43 leads one to expect that if 100% separation were specified to occur at, say, 16 years of service for a given grade, all officers of that grade with 16-31 years of service would be separated, but the program separates from the one year only. The coding in lines 066900-067200 and 072100-072400 is appropriate for rates greater than 9.000, but when the rate equals 9.000 new loops are needed with the years-of-service index going from the specified year I1 through 31.

Paragraph 3 on page 43 describes data cards that were not programmed for and are not necessary when the above modification has been made.

Line 4 from the bottom of page 43 implies that mandatory separation of officers with 1 or 2 years of service cannot be made, but the subroutine SEPP can separate officers with 1 or 2 years of service as long as the rate is greater than or equal to 9.000. It is only when the rate is less than 9.000 that the 1 or 2 year code is interpreted as Passover 1 or 2 (lines 065600 and 065700).

TYPE 10 DATA CARD. ACTIVE-DUTY RECALLS

According to the last paragraph on page 44, these cards are required only for years in which the recall policies are instituted or changed. However, they were needed for each year because the variables read from the cards were not put into COMMON and the subroutines VACADJ and EDIT5 were unable to use the previous year's data.

The maximum number of Type 10 cards for a given year was dimensioned as 10 in the program, but this was not mentioned in the Guide.

REASONS FOR VARIATIONS IN THE PROJECTION PRINT-OUTS

Most of the differences found between the printed tables themselves and between program output and results expected from hand calculations have now been traced to the following causes.

ROUNDING OFF NUMBERS

The entries in the inventory matrices were carried in the computer as floating point numbers instead of integers. When they were then converted to integers for print-outs, they were not rounded off consistently. Sometimes a column (or row) of such numbers was added first and the sum was rounded (line 040500) or not rounded (line 067300), and at other times the decimals in each cell were dropped before the sum was obtained (line 028700). Changes had to be made in all subroutines using decimal multipliers as in ATTRT, SEPP, PROMOT, and PROCUG.

COMPUTING AVERAGES

The first year of service or in grade is really the interval from 0 to 1 year, the second year is the interval 1-2 years, etc. The subroutine AVYIGD (lines 182300 and 188100) used the midpoint of each interval when computing average number of years of service and average number of years in grade. These averages were printed by EDIT4 and EDIT7. Subroutines AUTOPR (lines 153800 and 155320) and PROMOT (lines 164100 and 164400) used the end points of the intervals rather than the midpoints. Those averages were printed by EDIT6 and of course did not agree with the other set, even when they were based on the same officers.

USE OF IBOLT OPTION

The subroutine AUTOPR (line 154200) does not consider the IBOLT option of putting RA passovers into Passover 1 category when automatic promotions are called for on the Type 8 cards, but subroutine PROMOT (line 163600) does use the option when zone promotions are called for. This resulted in numbers being left in cells which should have been empty.

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DETERMINATION OF PROMOTION ZONES

The zones computed by the subroutine PROZON are longer than they should be because PROZON computes (line 140100) a fraction, H1, as that part of the year remaining from the cut-off month to the following June and considers only that fraction of the officers in the year-in-grade in which the cut-off year falls instead of 100% of them. In the case of the OTRA inventory, only officers not previously considered for promotion would be left in that year-in-grade since the promotees and the passovers have been moved out. The same is true of the RA inventory when IBOLT = 1, but when IBOLT = 0, the previous year's cut-off date and the rate of promotion must be known to determine accurately how many RA officers still in the year-in-grade are really passovers. This information may not be known for the first year of a projection. However, the fact that the Master Tape shows RA officers in both Passover 1 and the Passover 2 categories seems to contradict page 41 of the Guide which says that RA officers are returned to their year-in-grade classification if not selected for promotion. If both RA and OTRA passovers were to be put into the Passover 1 category, the IBOLT option could be eliminated.

PROCUREMENT METHOD

The subroutine VACADJ (lines 102900-103700) and PROCUG (line 221700) add all the numbers available instead of using the numbers from the seven sources in the order of the indicated priorities only as needed to fill grade vacancies. This procedure resulted in overstrength for some of the lower grades when such was not anticipated.

MANDATORY SEPARATION

The subroutine SEPP (line 067200) was not separating all officers in years of service greater than the year for which 100% mandatory separation was specified. Again, expected zero cells were not empty.

PROMOTION OF OTRA COLONELS

The misplacement of line 124500, which should have preceded line 124400, prevented the program from knowing the year of service from which to select OTRA colonels for temporary promotion.

POSSIBILITY OF TYPE 8 CARD'S BEING MISSING

When no promotion is initially specified for a grade, the computer prints errors. Line 137900 should be followed by a new statement:

IF (TEMPR(IO).EQ.0) GO TO 7.

SHORTCUTS POSSIBLE IN RAC PROGRAM

It is certainly true that no two programmers would program this model in the same way and that even one programmer would do it differently now from at a later date; it is not surprising that there are some parts of the coding that will be changed in the revised SIMPO II model in the interest of reducing run time. Some of the changes are:

1. The present RA and OTRA inventory entries will be declared INTEGER instead of REAL with a saving of 2418 memory locations. Any equation in which an inventory-cell entry is multiplied by a fraction will contain the rounding-off factor of +.5 so that the result can be stored as an integer directly.

2. The row and column sums will be kept current at all times and will not be computed several times under different names as at present. The inventories will be dimensioned (32, 7, 14) from the beginning, at a saving of 718 locations of memory.

3. Renaming of variables will be kept at a minimum. In MANDSP, e.g. (lines 055800-061600), 48 statements were used to rename the variables for six CALL statements. None was required, however, since the CALL statements can be written in terms of the original variables immediately. Thus, line 056600 would be CALL SEPP (K1,IYR1,SEP1,K11, IYR11,SEP11,1).

4. Duplicated operations will be eliminated in a number of places such as:
   ● Recalls are now computed in both VACADJ AND EDIT5;

   ● RA and OTRA inventories for each of the six grades are combined five times although only one grade is needed each time (lines 139100-139400).

   ● Attrition losses are held in COMMON in both floating point and integer form, using 896 locations that will be saved when integers only are used and

   ● Programming for recalls to RA (line 102400) will be omitted since page 44 of the Guide says recalls apply to OTRA only.

5. Seven subroutines will be eliminated and their functions inserted where needed. These are EQ, TOTAL, ZERO, MADD, MSUBT, MMULT, and MSUMC. It is hard to justify a subroutine EQ when it is easier to write A = B than it is to write CALL EQ(A,B). Three others will be eliminated when SUBTOT is made part of VACADJ, MAGE is made part of MAGCAL, and XFR is made part of TRANS. The remaining subroutines will be organized into fewer overlays as a result of the reduced memory requirements for COMMON.

NEW FEATURES OF THE REVISED SIMPO-II MODEL

Before it was decided to make a major SIMPO-II revision that will include all the following features as well as many shortcuts in coding, the capability of the converted RAC model was extended by the inclusion of the first five features of those listed below:

1. When writing the Summary Tape, an option was added to use only active federal commissioned service for OTRA officers instead of their total active federal service.

2. The number of mandatory separation rates (Type 9 Data Cards) per projection year for each grade within a component was increased from five to nine.

3. The zone promotion logic was modified to exclude from consideration officers without a specified minimum number of years in grade. The minimum number of years is punched in Field 5 of the Type 8 Data Card and becomes the lower limit of the zone unless this lower limit is reached sooner.

4. Transfer logic was modified to prohibit transfer of OTRA officers having only one year in grade.

5. The procurement logic and the Type 6 Data Card have been changed to eliminate the source 7 (Miscellaneous) and to add two sources, namely, source 7 called Mandatory RA with a fixed priority of 1 and source 8 called Mandatory OTRA with fixed priority 2. The number of officers available from these two sources are to be procured regardless of vacancies. Any remaining vacancies will be filled from the sources given priorities 3 to 8. Open procurement of 2LT is designated 999999 in the priority 8 position. The assignment table on page 37 of the Guide is to be changed to eliminate Miscellaneous 10% 90% and to add Mandatory RA 100% 0% and Mandatory OTRA 0% 100%.

The vacancies of CPT, 1LT, and 2LT will be reduced in VACADJ by the number in the mandatory positions and then the need for further procurement will be determined and accomplished in PROCUG. Each inventory will be adjusted only once per grade instead of seven times per grade as now (lines following 223100).

6. The option of using quarterly rates will be added with the variable IQTR to be punched 1 in column 17 of the Type 1 Data Card if quarterly projections are to be made and punched 0 if annual projections are to be made. The restriction of 10 projections will be removed by reading in only one set of authorized strengths at a time. It will thus be possible to make any number of projections desired. A small program has been written to convert presently available annual rates to quarterly rates by means of the formula, $RATE_Q = 1. - \sqrt[4]{1. - RATE_A}$.

When using the IQTR option, the inventories will be aged in only periods 4, 8, and 12; and in the case of passovers, they will be left in year-in-grade until periods 4, 8, and 12 if desired.

7. The beginning inventories will be checked for officers in year-in-grade cells that exceed the cut-off dates for zone promotion and will be added to the Passover 1 category; this procedure will be applied to all OTRA officers and, if it appears desirable, to all RA officers as well.

8. New promotion logic will be written ·· provide that the total number to be considered in a grade will be apportioned among the Pass-over 1s, those in the prime zone, and those in the year before the prime zone for early promotees. The temporary promotion rate shown on the Type 8 Data Card will then be applied to each of the three groups. Those not selected from the Passover 1s will be put into Passover 2, and Passover 1 category will be zeroed out. Those not selected from the prime zone will be put into Passover 1, and those not selected from the early zone will remain in their year-in-grade classification. The percentages to come from each of the three groups (or at least two of them) will be added to the Type 1 Data Card.

9. The death (DEA), disability (DIS), and resignation-retirement (RANDR) rates on the Type 5 Data Card were, in effect, compounded by the subroutine ATTRT into one voluntary attrition rate equal to

$$1. - ((1. - DEA) * (1. - DIS) * (1. - RANDR))$$

since the inventory was decreased by the product of each rate in turn. Actually each rate should have been applied to the same inventory, a procedure equivalent to adding the three rates. However, since separate rates are not generally obtainable, Fields 5 and 6 of the Type 5 card will be omitted, as well as the Type 11 and 12 Data Cards which were designed to indicate changes in the death and disability rates.

CONCLUSIONS

The computer program for RAC 10-year model has been successfully converted to operate on the CDC-3300. BESRL has been called upon to exercise this model on their computer in behalf of three DCSPER Directorates. A continuing requirement for this model, or its successor, appears to exist in DCSPER, particularly in the Directorate of Procurement and Distribution.

Army experience with this model, one of the first simulation models to be successfully created by a contractor for Army use, has led BESRL personnel to the following conclusions:

(1) Contracts for the development of manpower/personnel system simulation models should include provision for the installation and maintenance of these models in the operational environment.

(2) A continuing interaction between modelers and DCSPER and/or OPO analysts, after the programming of the initial model, is required to provide eventually a fully useful model for use in evaluating alternative policies. The use envisaged when analysts and policy makers are thinking in terms of a manual model is not the same as will result when a computerized model is produced. The requirement for a change in the model will almost inevitably result from this change.

(3) The RAC documentation for their model was, on the whole, excellent. Yet a number of documentation errors floated to the top during utilization. The users of such a model must have a systematic procedure for updating the documentation of all active models.

(4) When changes to an actively used model continue over 18 months or more, the accumulated changes are apt to decrease the efficiency of the model to the point that redesign and reprogramming of the model are highly desirable. In the case of the model being reported here, the cost of redesigning and reprogramming the model is no more than the original conversion cost, but only because the personnel making the conversion were available to make the design modifications.