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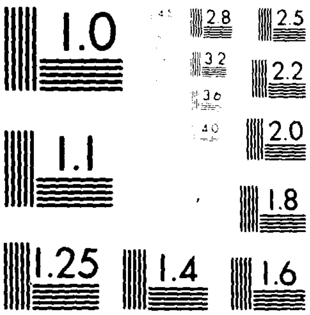

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AIR FORCE PERSONNEL AVAILABILITY ANALYSIS: PROGRAM DESCRIPTION FOR THE PERSONNEL AVAILABILITY MODEL (PAM)

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Wright-Patterson Air Force Base, Ohio 45433

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This report has been reviewed by the Office of Public Affairs (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

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Logistics and Technical Training

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Commander

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This is the third of three technical reports describing a methodology for projecting the future availability of Air Force personnel and analyzing the potential impacts of personnel policy changes. Developed within the Air Force Human Resources Laboratory Project 1959, "Advanced System for the Human Resources Support of Weapon System Development," the methodology will provide the Air Force with an increased capability for considering and determining the human resources requirements of weapon systems in terms of the future availability of personnel.

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Technical report AFHRL-TR-79-66 described the development of that methodology which includes a computerized Personnel Availability Model (PAM) and its associated data bank. Report AFHRL-TR-79-67 described application techniques to improve the accuracy of the PAM. This report (AFHRL-TR-79-68) provides a description of the computerized PAM programs including an applied PAM analysis of Air Force personnel.

SUMMARY

BACKGROUND

The satisfaction of the following needs is necessary to assure that future weapon system operational requirements are met.

1. Estimation of the quantity of personnel required for the implementation of future weapon systems.
2. Identification of possible difficulties in fulfilling future personnel requirements.
3. Defined and developed corrective actions to avert, or at least diminish the effect of personnel shortages on future weapon system operation.

As part of satisfying these needs, this technical report describes a means of projecting the future availability of Air Force personnel on the basis of historical data from Uniform Airman Records. At the core of the methodology is a personnel availability model. Computer programs were written to implement the methodology. This report provides a description of the programs with a sample session at a terminal.

APPROACH

The Personnel Availability Model methodology (described in technical report AFHRL-TR-79-66) and the related application techniques (described in report AFHRL-TR-79-67) were applied to airmen in selected maintenance Air Force Specialty Codes to project their future availability. In addition, a hypothetical human resource requirement for an Advanced Medium Short Takeoff and Landing (STOL) Transport (AMST) was generated. The projected future availability for one of the Air Force Specialty Codes was then compared to the future requirement for airmen with that specialty code.

RESULTS

The future availability of airmen in 13 selected maintenance AFSCs were projected for the years 1977 to 1984, 1990, 1995, and 2000. The PAM model projective capability improvement techniques were then applied to one broad group of those airmen (AFSC 328XX). For that group of airmen, and apparently all airmen with technical AFSCs, the techniques indicated that there were no impacting attributes other than years of service and paygrade.

A comparison was then made between a hypothetical full deployment (1988) human resource requirement for an AMST-like aircraft and its projected human resource availability. This comparison involved airmen holding a 328x4 AFSC and AMST related (C130 aircraft) experience, based on 1975 Uniform Airman Records. Data base maintenance features of the model were used to replace the transition probabilities of the 328x4/C130 population with those of the entire 328X4 population (thus increasing the statistical accuracy of the estimates), and to incorporate an expected change in Air Force personnel policy affecting transition rates.

In summary, the application of the model demonstrates how projections of future personnel availability may be made and, subsequently, how these results may be applied to the problem of personnel planning. In addition, it demonstrates how the projective accuracy of the model may be improved both through statistical analysis of subpopulations and the reflection of expected Air Force personnel policy changes.

PREFACE

This is the third of three technical reports describing the Personnel Availability Model (PAM), its methodology, application techniques, and computer programs. The model has been designed for use in the projection and analysis of the future availability of Air Force personnel. Work was performed under USAF Contract No. F33615-77-C-0032.

Technical report AFHRL-TR-79-66 represents the development and functions of the model along with its related data bank. Report AFHRL-TR-79-67 describes application techniques of the model. This report (AFHRL-TR-79-68) concludes this series of technical reports by providing a program description which includes an applied PAM analysis of Air Force personnel.

Work was directed by the Advanced Systems Division, Air Force Human Resources Laboratory, Wright-Patterson Air Force Base, Ohio. It is documented under Work Unit 19590003 of AFHRL Project 1959, "Advanced System for Human Resources Support of Weapon Systems Development." Dr. William B. Askren was the Project Scientist. Mr. H. Anthony Baran was the Work Unit Scientist and Air Force Contract Manager. Mr. John Goclowski was the Contractor Program Manager.

Work Unit 19590003, "Air Force Maintenance Personnel Availability Analysis," was undertaken to provide the Air Force with improved tools and techniques for anticipating the future impact on its personnel force structure resulting from the human resource requirements of new weapon systems.

Appreciation is extended to Dr. Gordon A. Eckstrand and Dr. Ross L. Morgan of the Advanced Systems Division for their guidance in constructing the modeling system described in this report, and to Dr. Robert A. Bottenberg of the Computation Sciences Division of the Air Force Human Resources Laboratory for his help in obtaining the personnel data essential to its operation.

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INTRODUCTION

This report is the last of three technical reports which describe the development, methodology, and application of a model for estimating the future availability of Air Force personnel. This report provides a program description of the Personnel Availability Model (PAM), including a PAM analysis of Air Force personnel.

The purpose of this introductory section is to provide a basic description of the PAM, an overview of the PAM methodology, and an outline of the remaining sections in this report.

THE PAM DESCRIPTION

The Personnel Availability Model (PAM) was developed to:

1. Aid in the evaluation of current human resources (HR) in the USAF.
2. Project future HR availability (HRA)
3. Compare HR availability (HRA) to the HR requirements (HRR) of specific weapon systems and indicate quantitative differences between them
4. Suggest policy changes that might be used to balance HRA and HRR

The complete PAM consists of three elements--a set of computer programs, a data base, and analytical techniques as follows.

computer programs	Used for making the required HR projections.
data base	For use in development and test of the PAM, the data base was extracted from the 1975-1976 Uniform Airman Records (UARs) of approximately 95,000 airmen assigned to 13 specific technical Air Force Specialty Codes in those years. For other analyses, any appropriate set of UAR data can be used.
analytical techniques	Designed to aid in the systematic selection of subpopulations for detailed study to provide more accurate projections.

The PAM is operationally divided into two segments. The first of these is the data base generation segment. It selects personnel records according to user defined criteria such as Air Force Specialty

Code (AFSC), Special Experience Identifier, marital status, and so forth. It also produces summary statistics in the form of state matrices (force strength classified by year of service and paygrade), transfer matrices (including recruits), and transition probability matrices. The second segment performs the population projection and allows for on-line data base management.

OVERVIEW OF PROGRAM DESCRIPTIONS

The remainder of this report is divided into two major sections describing two PAM programs. The first section, entitled "Data Base Generation," describes the COBOL/FORTRAN program (PROGRAM 1) which performs the function of selecting specific personnel records based upon user-supplied criteria. The second section, "Extrapolation, Data Base Maintenance, and Post-Processing," provides descriptions of the three functions named in the section title. These functions operate as subroutines of PROGRAM 2. The extrapolation function predicts future personnel transitions based upon historical probabilities; the data base maintenance function allows for modifications of subpopulation matrices prior to extrapolation; and the post-processing function provides a printout of the desired model outputs. Refer to Figure 1 for an overview of these functions in the PAM design. Note that each function is indicated on the figure with a reference letter, A through D. The following list shows the reference letter, function and language used for each function. COBOL is used for file maintenance facility. For mathematical functions, FORTRAN is used because it is the standard language on the Wright-Patterson CDC6600 and the DRC H-66/20.

	PROGRAM 1	
A	Data Base Generation	COBOL and FORTRAN
	PROGRAM 2	
B	Extrapolation	FORTRAN
C	Data Base Maintenance	FORTRAN
D	Data Post-Processing	FORTRAN

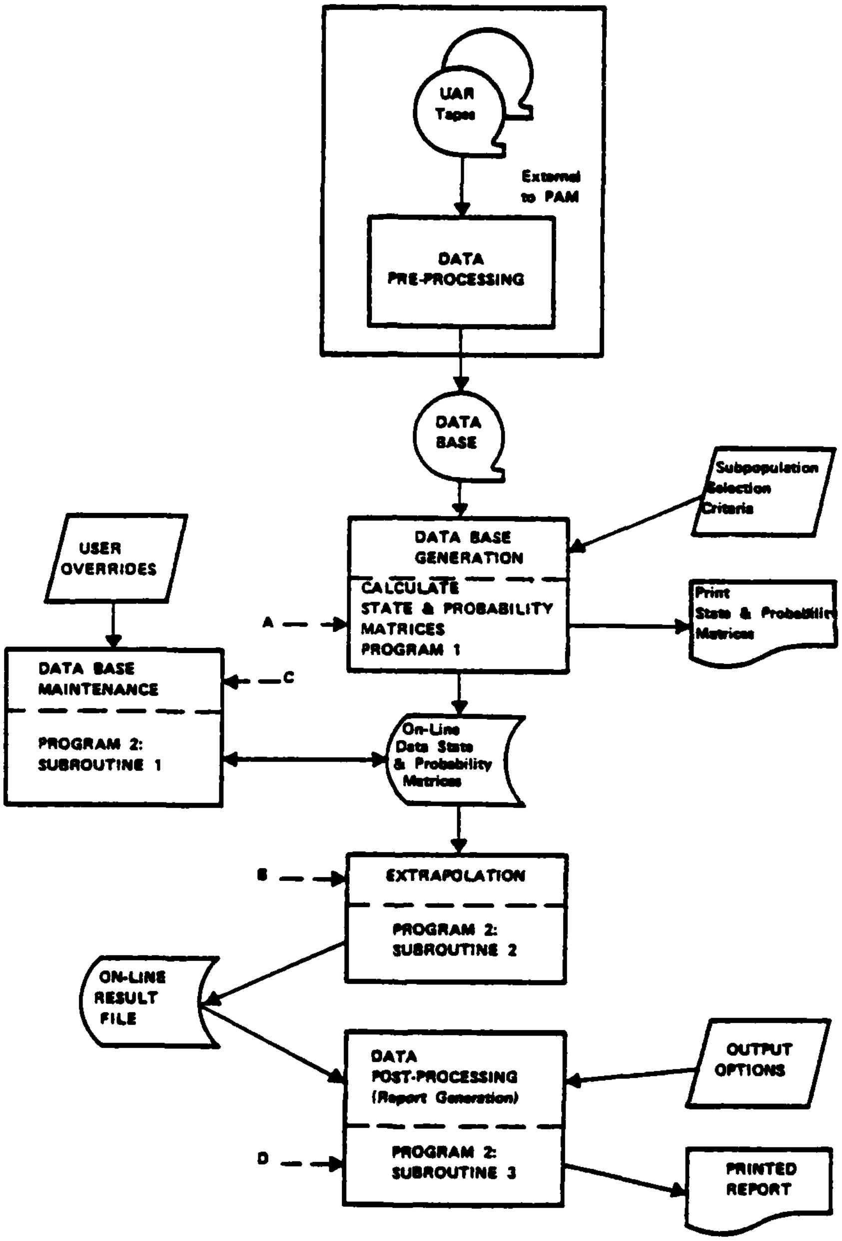


Figure 1 – The PAM design.

DATA BASE GENERATION - PROGRAM I

PROGRAM I operates the data base generation function. It selects Uniform Airman Records (UARs) according to criteria supplied by the user. The records selected are processed to create matrices for use by the extrapolation program. Once the records have all been processed, the program calculates probabilities (P) of upgrade, increment, transfer-in, transfer-out, and loss for each Air Force Specialty Code (AFSC), paygrade, and year of service (YOS). Probability of upgrade (PU) is calculated as:

$$PU_{i,j} = \frac{\text{Number of airmen paygrade i with j years of service promoted during the year}}{\text{Total population with paygrade i and year of service j}} = \frac{NU_{i,j}}{S_{i,j}}$$

Probabilities of increment (PI), loss (PL), and transfer-out are calculated in a similar manner. The program also accumulates matrices for the number of transfers by AFSC, years of service, and paygrade.

PROGRAM I DESCRIPTION

PROGRAM I accomplishes the data base generation function with two subprograms. The first subprogram, written in COBOL, selects the records. The second subprogram, written in FORTRAN, calculates the probabilities and builds the matrices. These subprograms extract and build a subpopulation file for a user-specified AFSC/matrix combination. (Note that with 13 AFSCs and 10 matrices, 130 combinations are possible.) The user indicates, with codes, the selection criteria for each attribute desired on input cards. All tape records are checked against these criteria for a match and all selected records are stored in the state matrix. Calculations are performed to determine probabilities of upgrade, increment, loss, and transfer.

The COBOL subprogram performs most of the input/output functions and determines if a record meets selection criteria. More specifically, the COBOL subprogram (a) reads and prints the record size and the field number of each field on the 1975 and 1976 UAR files; (b) reads, stores, and prints the selection criteria; and, (c) reads the input data and passes required data to the FORTRAN program by way of disk file.

The FORTRAN subprogram performs the calculations to determine the transition probabilities, writes the data to a disk file, and generates the report. More specifically:

1. It accepts data from the COBOL program and stores it in the appropriate matrix cell.

2. It determines movement, if any, from 1975 to 1976.

3. It calculates the probability matrices for loss, upgrade, transfer, and increment.

4. It writes the calculated data to the output disk file.

5. It prints the calculated data.

Refer to the supplement to this report for detailed flow charts of the COBOL and FORTRAN subprograms.

DESCRIPTION OF INPUT - The COBOL Subprogram

There are three input files to the COBOL subprogram.

1. A tape file which contains 1975 and 1976 UAR data

2. A disk file containing selection criteria for extracting data from the tape file on a specific subpopulation

3. A disk file which describes, for printing purposes only, the format of the tape file which can be:
   Tape File - UAR Data
   Disk Input - Selection Criteria
   Disk Input - Record Description of UAR Tape

A description of each follows.

Tape File - UAR Data

The tapes contain the merged abbreviated UAR data for 1975 and 1976. The social security number is not included on the file. (For a layout of the file, see Table 1.)

Disk Input - Selection Criteria

This disk file contains the parameters for the UAR record selection. The first card contains the printout options. The user can specify that one AFSC/matrix combination or the entire data set be printed.

The following is the code number, entitled AFSTYP, for each AFSC type currently in the file with its corresponding code.

AFSC	Code
325x0	01
325x1	02
328x0	03
328x1	04
328x4	05
328x0	06

Table 1 – PAM Input Record Layout.

Record Positions	Contents	UAR From	UAR Positions
1	PROFICIENCY PAY STATUS	1975	124
2	HAZARDOUS/SPECIAL DUTY STATUS – CURRENT	1975	132
3-8	AFSC–PRIMARY–NUMBER/SUFFIX	1975	214-219
9-14	AFSC–SECONDARY–NUMBER/SUFFIX	1975	225-230
15-20	SEE NOTE 1	1975	
21-26	AFSC–DUTY–NUMBER/SUFFIX	1975	251-256
27	ACAD INFO–HIGHEST LEVEL	1975	343
28-29	ACAD INFO–HIGHEST LEVEL – YR. ACHIEVED	1975	344-345
30	TRAIN STAT – NORMAL UPGRADE	1975	369
31-34	TRAIN STAT – ENTER/COMPL/WD DATE	1975	370-373
35	TRAIN STAT – METHOD OF MEETING UPGRADING	1975	374
36-37	TEST INFO – ADMINISTRATIVE SCORE	1975	382-383
38-39	TEST INFO – ELECTRONICS SCORE	1975	384-385
40-41	TEST INFO – GENERAL STORE	1975	386-387
42-43	TEST INFO – MECHANICAL SCORE	1975	388-389
44-46	TEST INFO – AFQT SCORE – GP/PERC//AFWST	1975	390-392
47-48	GRADE, CURRENT	1975	472-473
49-50	USAF SUPERVISORY EXAM – RESULTS	1975	559-560
51-54	TAFMS (TOTAL ACTIVE FED MIL SVC) DATE (YR-MO)	1975	567-570
55	RACE, SERVICE MEMBER	1975	613
56	SEX, SERVICE MEMBER	1975	614
57-62	BIRTH DATE	1975	618-623
63	MARITAL STATUS, SERVICE MEMBER	1975	633
64-65	DEPENDENTS – NUMBER	1975	636-637
66-68	SPEC EXPER ID – PASFC – 1st	1975	805-807
69	PROFICIENCY PAY STATUS	1976	124
70	HAZARDOUS/SPECIAL DUTY STATUS – CURRENT	1976	132

Table 1 — PAM Input Record Layout (continued).

Record Positions	Contents	UAR From	UAR Positions
71-76	AFSC — PRIMARY — NUMBER/SUFFIX	1976	214-219
77-82	AFSC — SECONDARY — NUMBER/SUFFIX	1976	225-230
83-88	SEE NOTE 1	1976	
89-94	AFSC — DUTY — NUMBER/SUFFIX	1976	251-256
95	ACAD INFO — HIGHEST LEVEL	1976	343
96-97	ACAD INFO — HIGHEST LEVEL — YR. ACHIEVED	1976	344-345
98	TRAIN STAT — NORMAL UPGRADE	1976	369
99-102	TRAIN STAT — ENTER/COMPL/WD DATE	1976	370-373
103	TRAIN STAT — METHOD OF MEETING UPGRADING	1976	374
104-105	TEST INFO — ADMINISTRATIVE SCORE	1976	382-383
106-107	TEST INFO — ELECTRONICS SCORE	1976	384-385
108-109	TEST INFO — GENERAL SCORE	1976	386-387
110-111	TEST INFO — MECHANICAL SCORE	1976	388-389
112-114	TEST INFO — AFQT SCORE — GP/PERC//AFWST	1976	390-392
115-116	GRADE, CURRENT	1976	472-473
117-118	USAF SUPERVISORY EXAM — RESULTS	1976	559-560
119-122	TAFMS (TOTAL ACTIVE FED MIL SVC) DATE (YR-MO)	1976	567-570
123	RACE, SERVICE MEMBER	1976	613
124	SEX, SERVICE MEMBER	1976	614
125-130	BIRTH DATE	1976	618-623
131	MARITAL STATUS, SERVICE MEMBER	1976	633
132-133	DEPENDENTS, NUMBER	1976	636-637
134-136	SPEC EXPER ID — PAFSC — 1st	1976	1111-1113

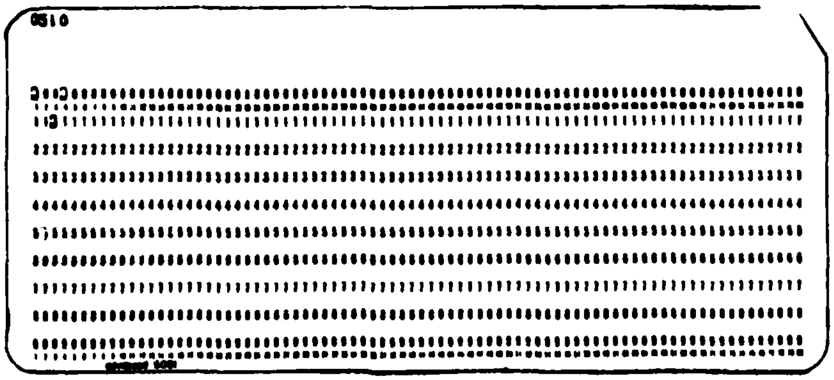
NOTE 1: If the Secondary AFSC = Duty AFSC (positions 1-3 and 5-6), then this field contains UAR positions 225-230 else this field contains UAR positions 214-219.

431x1E	07
431x1C	08
423x1	09
423x3	10
423x4	11
426x2	12
531x3	13
EXTRNL	14
All the above	15

The following is the code number, entitled MATTYP, for each matrix type with its corresponding code.

Matrix Type	Code
State Matrix	01
Probability Loss	02
Probability Transfer Out	03
Probability Transfer In	04
Probability Increment	05
Probability Upgrade	06
Personnel Loss	07
Personnel Transfer Out	08
Personnel Transfer In	09
Personnel Increment	10
Personnel Upgrade	11
All the above	12

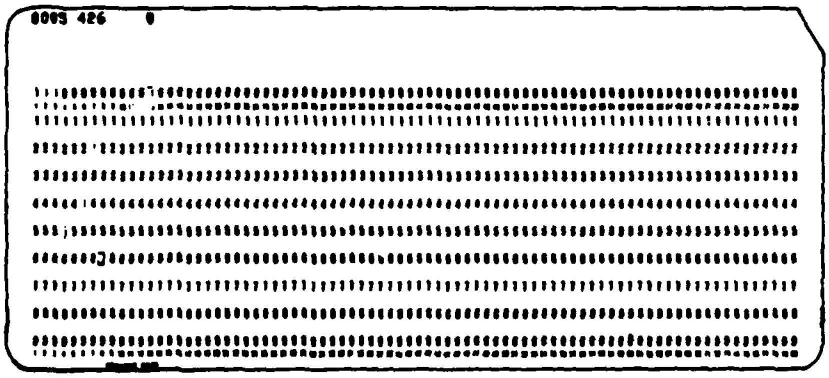
Specification of the subpopulation is accomplished by indicating the appropriate codes on Card #1. The codes then are automatically transferred to the FORTRAN program. For example, the following card specifies the personnel Increment Matrix (Code 10) for AFSC 328x4 (Code 05).



The remaining cards specify the selection fields and their parameters. A single selection parameter consists of four user-specified codes--FLDNO, RECYR, KEY-X, and TYPE. The following is a description of each variable.

FLDNO	The field number designation.
RECYR	Used to specify the reocrd year(s) to be processed. If RECYR is blank, the 1975 and 1976 halves of each record will be processed. If RECYR is equal to 1, only the 1976 half of each record will be processed.
KEY-X	The character string against which a field is compared. To select every record, enter ALL in card columns 6 and 8.
TYPE	Used to indicate the selection test, (> , =, <). The selection test may occur in one of three ways. • If TYPE = ƀ1, (ƀ indicates a space or blank character), the field must be < the key. • If TYPE = ƀƀ, the field must be = the KEY. • If TYPE = -1, the field must be > the KEY.

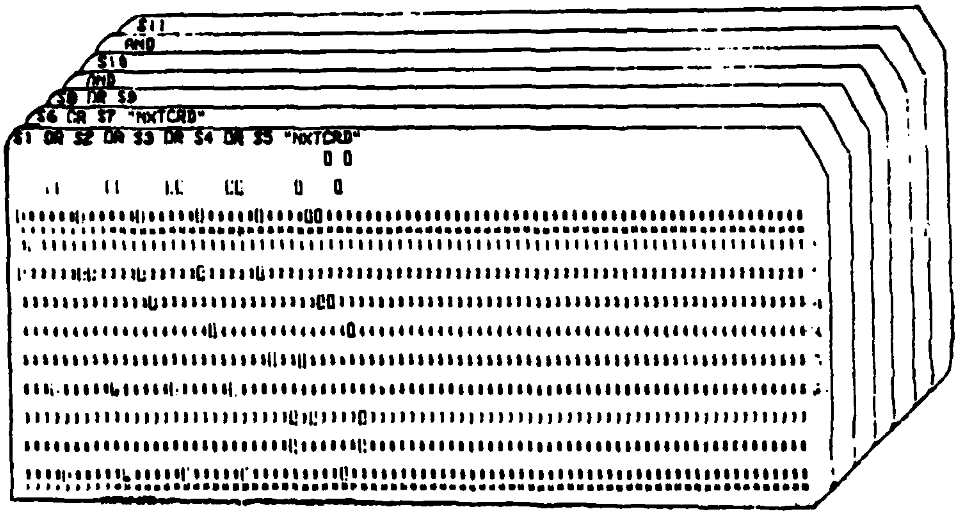
The following is an example of a selection parameter input card.



When more than one parameter is required for selection, the parameters are combined with the logical AND or the logical OR notation. The following guidelines should be used for AND/OR notation.

OR	To combine up to five parameters on the same card. More than five parameters may be linked with an OR by placing a continuation code (NXTCRD) in the next KEY-X field position. (It may be placed in card columns 71 through 76 as a sixth parameter.) The NXTCRD code is not placed on the last of a series of continued cards. It is used only on the first through the next-to-last cards. A maximum of 15 parameters may be logically joined with the OR using continuation cards.
AND	To combine parameters on different cards.

The following is an example of the nesting involved, where Sn is a selection parameter:



As stated above, an OR is assumed for all codes on a single card and an AND is assumed for all codes on separate cards. Once these cards are completely read into the program, cards 1 through 3 are considered to be Card 1, Card 4 is considered to be Card 2, and so forth. The cards are treated as logical cards rather than sequential cards during execution. Up to 15 selections may be joined by an OR and there may be up to 50 logical cards.

Disk Input - Record Description of UAR Tape

This disk input file contains a description of the records on the UAR tape file. Data are displayed for the user as an explanation of the fields given in the selection criteria. The subprogram simply reads an 80-character record and prints it. The header displayed prior to printing these records assumes that the following fields exist.

Field Number	Positions 11-12
Contents	Positions 21-70
Field Length	Positions 74-75

The description is the same for both halves of the record. The Field Number is the FLDNO field described in the selection criteria record.

DESCRIPTION OF INPUT - The FORTRAN Subprogram

There is one input to the FORTRAN subprogram. Extracts of the UAR records selected by the COBOL subprogram are input to this program. The records contain the following fields.

Field	Record Positions	Content
CODE	1	2, 3, or 5. 2 indicates that 1975 and 1976 data exist on the record. 3 indicates that only 1976 data exist. 5 indicates an End-of-File.
AFSTYP	2-3	AFSC Type
MATTYP	4-5	Matrix Type
AFSC 75	6-11	
AFSC 76	12-17	
YOS 75	18-23	
YOS 76	24-29	
GRADE 75	30-35	
GRADE 76	36-41	

Note that the AFSTYP and MATTYP indicate the AFSC/matrix combination.

DESCRIPTION OF OUTPUT - The COBOL Subprogram

There are two outputs from the COBOL subprogram.

1. A disk file containing extracts of selected records (refer to DESCRIPTION OF INPUT - The FORTRAN Subprogram - on page 17 for a description of the file)

2. A report containing the record descriptions and selection criteria input to this subprogram (see Table 2 for a sample of the report)

DESCRIPTION OF OUTPUT - The FORTRAN Subprogram

There are two outputs from the FORTRAN subprogram.

1. A report listing the results of calculations performed for each AFSD/matrix combination subpopulation selected (see Figures 2 and 3 for examples of this report)

2. A disk file containing data on the selected subpopulations of the AFSCs/matrices

COBOL AND FORTRAN JOB CONTROL LANGUAGE

The following pages contain listings of the job control language (JCL) necessary to access and run the COBOL and FORTRAN subprograms on the Wright-Patterson CDC-6600.

Table 2 - Sample Report Containing the Record Descriptions and Selection Criteria Input.

```
SUBPOPULATION CRITERIA

NO   RECYR   KEY   TYPE    SELFLD   RECYR   KEY   TYPE   SELFLD   RECYR   KEY   TYPE

01     75    421   Equal     05
02     75    2     Equal     07
```

```
                                        FOR AFSC 325X0

                                   Y E A R S  O F  S E R V I C E
         1    2    3    4    5    6    7    8    9   10   11   12   13   14   15   16   17   18   19   20   21
GRD ------------------------------------------------------------------------------------------------------------
     :
 9   :   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
     :
 8   :   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1
     :
 7   :   0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    1    0    0    0    2    6
     :
 6   :   0    0    0    0    0    0    1    0    0    0    0    0    2    1    1    1    1    1    1    1    1
     :
 5   :   0    0    0    0    0    1    0    1    5    2    0    1    0    1    2    2    1    1    1    0    1
     :
 4   :   0    0    0   15    6    1    1    1    3    0    0    0    0    0    0    0    0    0    0    0    4
     :
 3   :   6    0   15    0    0    0    0    0    0    0    0    0    4    0    0    0    0    0    0    0    4


                                        FOR AFSC 325X1

                                   Y E A R S  O F  S E R V I C E
         1    2    3    4    5    6    7    8    9   10   11   12   13   14   15   16   17   18   19   20   21
GRD ------------------------------------------------------------------------------------------------------------
     :
 9   :   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    4    7
     :
 8   :   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1
     :
 7   :   0    0    0    0    0    0    0    0    0    0    0    1    4    0    1    0    0    0    1    0    4
     :
 6   :   0    0    0    0    0    0    0    0    0    0    0    2    0    2    1    1    1    2    8    6    5
     :
 5   :   0    0    0    0    1    1    3    3    6    3    0    4    2    1    0    2    1    0    0    2    8
     :
 4   :   0    0    1   17   12    4    4    5    0    0    0    0    0    0    0    0    0    8    0    0    8
     :
 3   :  33    2   21   17    0    0    0    0    0    0    0    0    4    0    0    0    0    0    0    8    0
```

Figure 2 Sample state matrix.

```
                                                  FOR AFSC 32590

                                               Y E A R S  O F  S E R V I C E
        1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    17    18    19    20    21
GRD ------------------------------------------------------------------------------------------------------------------------------
     :
  9  : 0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.
     :
  8  : 0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.
     :
  7  : 0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.167
     :
  6  : 0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.333
     :
  5  : 0.    0.    0.    0.    0.    1.000 0.    0.    0.200 0.    0.125 0.    0.    0.    0.    0.    0.    0.    0.    0.    1.000
     :
  4  : 0.    0.    0.    0.067 0.333 0.    0.    1.000 0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.
     :
  3  : 0.    0.    0.133 0.375 0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.


                                                  FOR AFSC 32591

                                               Y E A R S  O F  S E R V I C E
        1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    17    18    19    20    21
GRD ------------------------------------------------------------------------------------------------------------------------------
     :
  9  : 0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.
     :
  8  : 0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.111
     :
  7  : 0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.
     :
  6  : 0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.500
     :
  5  : 0.    0.    0.    0.    0.    0.    0.    0.333 0.167 0.    0.125 0.    0.    0.    0.    0.    0.    0.    0.    0.    0.
     :
  4  : 0.    0.    0.    0.235 0.500 0.    0.    0.200 0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.
     :
  3  : 0.    0.    0.143 0.235 0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.
```

Figure 3 Sample probability loss matrix.

Listing 1:

Selection Program
COBOL Source File Name: PAM2SEL
Compile and Execute JCL: JCLSEL
JCL:

```
100-DRO,T300,CM100000,MTi,STOBB. H730402, PATKELLEY,
      6176586100
110-ATTACH,PAM2SEL,PAM2SEL,
120-COBOL(I=PAM2SEL).
180=LABEL,TAP1,R,L=PAMREO5 ,USN=LO256O,NORING.
140=ATTACH,TAPE 2,SELRED.
150=ATTACH,TAPE3, PAM2DAT.
160=REQUEST,TAPE4,WPF.
170=REQUEST,TAPE5, PF.
180=LGO
190=CATALOG,TAPE4,PAM2RPT,RP=99
200=CATALOG,TAPE5,MTXDATA,RP=99
210=*EOR
220=+EOF
```

Information necessary for understanding of Listing 1 is:

TAPE 1	The pre-processed UAR data (see Table 1 for format).
TAPE 2	The selection criteria.
TAPE 3	A description of the contents of TAPE 1 for use in creating TAPE 2.
TAPE 4	The report produced by this program. TAPE 4 lists the selection and TAPE 1 description of record fields.
TAPE 5	The selected records. This file is input to the matrix program.

Listing 2:

The following is a listing of SELREC (TAPE 2 - selection criteria).

```
1112
0005 421 0
0007 2   0
```

Listing 3:

The following is a listing of PAM2DAT (TAPE 3).

FLDNO (Field Number)		Columns
1	PROFICIENCY PAY STATUS	1
2	HAZARDOUS/SPEICAL DUTY STATUS - CURRENT	1
3	AFSC-PRIMARY-NUMBER/SUFFIX	6
4	AFSC-SECONDARY-NUMBER/SUFFIX	6
5	"CONTROL" AFSC POSITIONS 1-3	3
6	"CONTROL" AFSC POSITION 4	1
7	"CONTROL" AFSC POSITIONS 5-6	2

8	DUTY AFSC POSITIONS 1-3	3
9	DUTY AFSC POSITION 4	1
10	DUTY AFSC POSITIONS 5-6	2
11	ACAD INFO - HIGHEST LEVEL	1
12	ACAD INFO - HIGHEST LEVEL - YR ACHIEVED	2
13	TRAIN STAT - NORMAL UPGRADE	1
14	TRAIN STAT - ENTER/COMPL/WD DATE	4
15	TRAIN STAT - METHOD OF MEETING UPGRADE	1
16	TEST INFO - ADMINISTRATIVE SCORE	2
17	TEST INFO - ELECTRONICS SCORE	2
18	TEST INFO - GENERAL SCORE	2
19	TEST INFO - MECHANICAL SCORE	2
20	TEST INFO - AFQT SCORE - GP/PERC/AFWST	3
21	GRADE, CURRENT	2
22	USAF SUPERVISORY EXAM - RESULTS	2
23	TAFMS (TOTAL ACTIVE FED MIL SVC) DATE (YR-MO)	4
24	RACE, SERVICE MEMBER	1
25	SEX, SERVICE MEMBER	1
26	BIRTH DATE	6
27	MARITAL STATUS, SERVICE MEMBER	1
28	DEPENDENTS - NUMBER	2
29	SPEC EXPER ID - PAFSC - 1st	3

Note that in Listing 3, the numbers in the left column indicate the FLDNO (Field Number). The numbers in the right column indicate the field width.

Matrix Program
FORTRAN Source File Name: PAM2MTX
Compile and Execute JCL:JCLMTX

JCL:

```
100=DRO,T08,1011,CM140000,STOBB. H730402,PATKELLEY,61765866100
110=ATTACH,PAM2MTX,PAM2MTX.
120=FTN(I=PAM2MTX).
130=ATTACH,TAPE20,MTXDATA.
140=REQUEST,TAPE10,*PF.
150=REQUEST,TAPE30,*PF.
160=LGO.
170=CATALOG,TAPE10,PAM2OUT,RP=99.
180=CATALOG,TAPE30,PAMRPT2,RP=99.
190=*EOR
200=*EOF
```

Information necessary for understanding of Listing 3 is:

TAPE 10	The data file for input to the extrapolation function subroutine (further detailed in the next section).
TAPE 20	The selected records which are input to this program.
TAPE 30	The generated report based on the AFSC/matrix combination requested in the first record of the SELREC file.

EXTRAPOLATION, DATA BASE MAINTENANCE, AND POST-PROCESSING FUNCTIONS - PROGRAM 2

The extrapolation, data base maintenance, and post-processing functions of the PAM are accomplished with PROGRAM 2. This program (a) extrapolates future losses and retentions stored by paygrade, years of service, and projection year; (b) allows user modifications to be made to any of the subpopulation matrices which can then be processed by the extrapolation model for comparison with the results obtained from the original data; and, (c) provides the user with a printout of the model results and/or the current values in any of the subpopulation matrices.

PROGRAM 2 DESCRIPTION

PROGRAM 2 is an interactive FORTRAN program compiled and run under CDC Intercom. Program control is based in the main routine with branching, as directed by the user, to four subroutines. The subroutines are MAINT (maintain), RUN, PRINT, and END. Each may be operated in any order requested by the user. However, note that if a request is made to print results (rather than subpopulation matrices) before the model has been run for the current data matrices, the program will display meaningless data which may cause a system error if the file is empty.

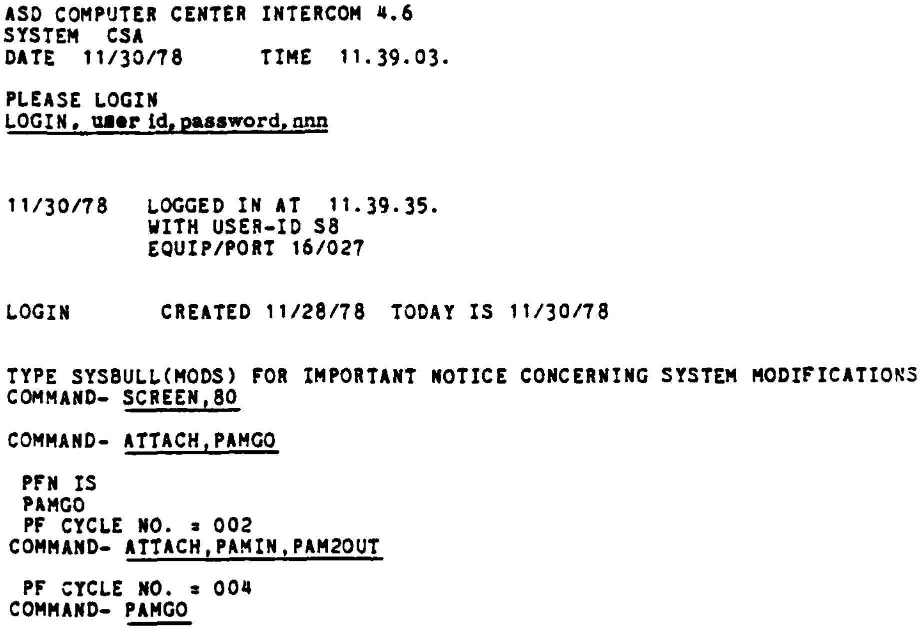
The following is a brief description of the main program and subroutines.

PROGRAM 2

1. Initializes and sets I/O parameters for the terminal.
2. Attaches a data file and loads the values from that file into the state and probability matrices.
3. Rounds-off probabilities to three decimal places.
4. Identifies requested functions (MAINT, RUN, PRINT, or END) and calls the appropriate subroutine.
5. Stores maintained (modified) matrices in a data file, if requested.
6. Reloads unaltered data bank into the subpopulation matrices, if requested.

Subroutine MAINT

1. Provides element-by-element on-line editing of the subpopulation matrices with a strictly enforced check which prevents unreasonable probability sums (such as not equal to one).



```
ASD COMPUTER CENTER INTERCOM 4.6
SYSTEM  CSA
DATE  11/30/78      TIME  11.39.03.

PLEASE LOGIN
LOGIN, user id,password,nnn


11/30/78   LOGGED IN AT  11.39.35.
           WITH USER-ID S8
           EQUIP/PORT 16/027


LOGIN       CREATED 11/28/78  TODAY IS 11/30/78

TYPE SYSBULL(MODS) FOR IMPORTANT NOTICE CONCERNING SYSTEM MODIFICATIONS
COMMAND- SCREEN,80

COMMAND- ATTACH,PAMGO

 PFN IS
 PAMGO
 PF CYCLE NO. = 002
COMMAND- ATTACH,PAMIN,PAM2OUT

 PF CYCLE NO. = 004
COMMAND- PAMGO
```

Figure 4 Initial procedures for the Wright-Patterson CDC6600.

2. Allows user flexibility and facility in performing modifications in any order desired, subject to the probability sum restriction

Subroutine RUN

1. Executes the extrapolation model for the requested number of projection years

2. Stores the matrix RESULT in a result file and detaches the file

Subroutine PRINT

1. Determines the requested output type (such as results and/or subpopulation matrices).

2. Lists requested data in a format determined by print control parameters entered on-line.

Before executing PROGRAM 2, the user must attach the following two files to be used during execution of the program.

PAM	A data file containing the subroutine matrices from the data base generation function.
PAMOUT	A file which stores the results from a run of the extrapolation model in subroutine RUN. Refer to Figure 4 for the initial procedures to run the PAM on the Wright-Patterson CDC6600 with the data currently stored in file PAMOUT. (User input is underlined.)

DESCRIPTION OF INPUT

The information on the following pages contains input and output descriptions for each subroutine, including computer/user dialogues. Note that user responses within a display are underlined (specifically, in the DESCRIPTION OF OUTPUT section).

There are two types of input to PROGRAM 2.

1. A disk file containing the subpopulation matrices of state, transfer, and related probabilities output from the PAM.

2. User-supplied parameters and control instructions to direct the extrapolation, maintenance, or print functions performed by the PAM.

The latter are entered by the user at the terminal in response to prompting questions issued by the PAM. The PAM requires user input for the direction of execution through a choice of options or for specific parameters required to perform the task at hand. Each time user input is required, a statement followed by a question mark is displayed to prompt the user. At this point, program execution pauses, awaiting the user response. Execution resumes once the user enters a response and depresses the carriage return key.

Initially the PAMIN file is accessed in the program and the data stored in the PAM2OUT file (from the data base generation function) is read into the six matrices--ST, TI, TO, PL, PU, and PI. The dialogue is initiated when the following question appears on the terminal.

```
MAINT, RUN, PRINT, OR END?
```

There are four possible replies to this question. They are:

M	Directs control to the subroutine MAINT and leads to a series of questions related to the maintenance process.
R	Directs control to subroutine RUN for a run of the extrapolator model.
P	Directs control to subroutine PRINT for printing of the current values contained in the state, transfer, or probability matrices; or, for printing results following a run of the model.
E	Terminates program execution.

When an activity initiated by the replies M, R, or P has concluded, control returns to the main program and the initial question appears again. In any run of the PAM, the user will encounter this question several times.

USER NOTE:

It is recommended, for each new data base generated, that the first command given be P (PRINT). In addition, a copy of the initial state matrix should be produced in the manner described below. The purpose of this is to make sure that there are sufficient personnel in the state matrix to allow for accurate predictions. The user should refer to AFHRL-TR-79-67 for procedures to be followed in performing this check.

After a satisfactory state matrix is produced, proceed with the projection process. If small numbers are encountered, the user may elect to choose a new subpopulation (for example, generate another new data base) or make the necessary changes in any matrix to circumvent the problem using the maintenance features discussed in this report.

DESCRIPTION OF INPUT - MAINT

The following pages contain explanatory notes for the question/answer sequences encountered in the subroutine MAINT. This process begins with the user prompt:

```
MAINT, RUN, PRINT, OR END?
```

Enter an M to initiate the maintenance process. The following question is then displayed.

```
MATRIX NAME?
```

Note that MATRIX NAME is the highest level of control in the MAINT subroutine. At this point, enter the name of the matrix to be modified. This response may be one of the following.

ST	State Matrix
TI	Transfer-In Matrix
TO	Transfer-Out Matrix
PL	Probability-of-Loss Matrix
PU	Probability-of-Upgrade Matrix
PI	Probability-of-Increment Matrix
EN	Terminate maintenance and determine what additional processing of the modified matrices is desired.

After entering the matrix name, the following question appears.

```
GRADE, YOS?
```

This question requires the input of an ordered pair of integers to specify which element of the designated matrix is to be modified. The range of GRADE (paygrade) is from 3 to 9; the range of YOS (years of service) is from 1 to 21. The numbers must be separated by a comma or blank space. For example, possible responses are 3,1 or 3 1 (GRADE 3 and YOS 1).

Once a matrix name has been entered for modification, the MAINT subroutine assumes that more than one single element of the designated matrix is to be modified. The GRADE, YOS question appears again after alteration of an element has been completed. At this point, specify any additional element to be modified. Otherwise, nonstandard, but optional, replies to this question are as follows.

EN	To terminate the MAINT subroutine.
MA	To end modification of the current matrix and begin modification of another. The MATRIX NAME question again appears.

If the user responds to GRADE, YOS with an ordered pair of integers, the program displays the name of the matrix, the grade, the years of service, and the current value of the specified element in the following format.

```
(Matrix Name), GRADE (Grade) -- (Years of Service) YOS
CURRENT VALUE = XXXXXXXX
```

The items enclosed in the parentheses are those entered in response to MATRIX NAME and GRADE, YOS questions. Next, the user will be asked:

```
NEW VALUE?
```

The standard reply to this question is an integer value if matrices ST, TI, or TO are being modified; or, a decimal value (x, x: $0 \leq x \leq 1$) if matrices PL, PU, or PI are being modified.

Nonstandard replies to the NEW VALUE question should be made only if the user decides, at this point, to avoid making the replacement which is in progress. Options include the following.

EN To end the MAINT subroutine, but retain the modifications made for further processing. The user is prompted again with the GRADE, YOS question.

GR To continue modifying the specified matrix, but for a different element. The user is prompted again with the MATRIX NAME question.

If the user responds to NEW VALUE with a numeric entry of the same type as the data within the specified matrix, the following lines are displayed.

```
REPLACING (Current Value) WITH (New Value)
Y or N?
```

The items enclosed in parentheses correspond to the numeric values which are displayed. A response of Y causes the change to be made and returns control to the GRADE, YOS level, assuming that the next change to be made (if any) is to be performed upon the previously specified matrix. A response of N returns control to the MATRIX NAME (highest) level. As in previously stated options, the user may override this replace option by entering EN or MA.

The MAINT subroutine continues to operate until the user enters a response of EN to any of the questions--MATRIX NAME?, GRADE,YOS?, or NEW VALUE?. However, if changes are made to any of the probability matrices, the elements of the same paygrade and years of service in the other probability matrices must be adjusted to preserve their sum equal to 1. The MAINT subroutine enforces this requirement. After modification of a probability matrix, control will not pass to the GRADE,YOS level, but will inform the user of the current sum of the corresponding probability elements and will request that the necessary adjustment be made. This procedure is displayed as:

```
PL, PU, PI, AND PT AT GRADE (XX) = (YY) YOS:
(P1) + (P2) + (P3) + (P4) = (SUM)
ADJUST PROBABILITIES SO THAT SUM = 1,000
MATRIX NAME?
```

At this point, the MAINT subroutine only accepts the name of one of the probability matrices. Any other response (including EN) is ignored and the request to adjust a probability is re-issued. After this enforcement condition is met, normal processing recommences. (Note that PT is a calculated value which cannot be adjusted during this process.)

After terminating MAINT by entering an EN response at any appropriate level, the user is prompted with the following question.

SAVE MAINTAINED FILES (Y OR N)?

Respond with Y to replace the data in the subpopulation file with the revised data and pass control back to the main routine. If any other response is entered, the following question is displayed.

RELOAD OLD FILES (Y OR N)?

When a response of Y is entered, the PAM reloads the data from the subpopulation file back into the matrices used in the program, cancelling all modifications and passing control back to the main routine. Any response other than Y returns control to the MAINT, RUN, PRINT, OR END level.

DESCRIPTION OF INPUT - RUN

Enter an R at the MAINT, RUN, PRINT, OR END level to initiate the RUN process. The following question is then displayed.

HOW MANY PROJECTION YEARS ARE DESIRED FOR RUN?

In response to this question, enter an integer from 1 to 10. The model runs for the specified number of years, and when completed, the following message is printed.

RUN COMPLETED

Control then returns to the MAINT, RUN, PRINT, OR END level.

DESCRIPTION OF INPUT - PRINT

The PRINT process is initiated by a response of P at the MAINT, RUN, PRINT, OR END levels. The PRINT question/answer sequence then begins with the following prompt.

RESULT, MATRIX, OR END?

To examine the results from the previous run of the model, enter an R. The program flow continues by the PRINT control parameters. These parameters are paygrade, years of service, and projection years. The first parameter prompt is displayed as:

PAYGRADES?

Two optional responses are applicable. They are non-numeric entry and numeric entry, as explained below.

Non-numeric entry	The user may enter ALL or COL as a non-numeric resonse to the PAYGRADES question. ALL causes the result printout to be displayed for all paygrades, 3 to 9. COL causes the results to be displayed as collapsed by paygrade such that all of the paygrade columns are summed horizontally and shown in a single column.
Numeric entry	The user may enter two integers in the range of 3 to 9. However, the first integer must be less than or equal to the second integer with the entries separated by a comma. The results will be printed for the requested paygrades.

After a non-numeric or numeric response is entered for the paygrade parameter, the following question prompts for the years of service parameter.

YEARS OF SERVICE?

The optional responses for this question are similar to those of the PAYGRADE question. They are:

Non-numeric entry	ALL displays results for all years of service, 1 to 21. COL displays results by years of service, with all of the rows in the result matrix summed to a single row.
Numeric entry	The user may enter two integers in the range of 1 to 21, corresponding to the lowest and uppermost value desired for years of service in the listing of results.

When COL is entered for the PAYGRADE and YEARS OF SERVICE questions, the output is summed across both paygrade and years of service. It will consist of two values (state and losses) for each projection year displayed.

The final PRINT parameter is then prompted as a response to the following question.

PROJECTION YEARS?

The program accepts numeric responses and will anticipate two integer values (M and N) separated by a comma. Because M and N are used for print control of the lower and upper bounds respectively, M must be less than or equal to N. The following options are applicable.

1. If M and N are greater than 1900, the results are printed for calendar year M through calendar year N. In this case, M and N must lie in the range of 1975 through 1975 + NOYRS, where NOYRS is the number of projection years used for the last run of the model prior to print.

2. If M and N are less than 1900, the results are printed for projection year M through projection year N. In this case, M and N must lie in the range of 1 through NOYRS.

Once the user has entered all of the information necessary for the printing of results (the print control parameters for paygrades, years of service, and projection years), the program will display a series of tables, one for each successive projection year requested. Each element of the tables consists of two values--retentions (state) which are displayed as the upper left portion of each element and losses which are displayed as the lower right portion. This method of display shows the result matrix as a super-position of its two submatrices, the state and loss matrices.

After the results have been listed, processing control returns to the RESULT, MATRIX, OR END level. RESULT subpopulation matrices may be listed in any order desired, and the print process will continue to cycle through these questions until the user sends control back to main program by entering an E in response to the RESULT, MATRIX, OR END question. If the user enters an M as the response to this question, the following prompt is displayed.

MATRIX NAME?

Enter the name of any of the six subpopulation matrices (ST, TI, TO, PL, PU, or PI) to generate printout of the current elements. (Entering EN returns control to the main program.) The requested matrix is labelled and listed, followed by the question:

PRINT ANOTHER MATRIX (Y OR N)?

A response of Y returns control to MATRIX NAME. Any other response results in the following question.

PRINT RESULT (Y OR N)?

A response of Y is treated exactly as if the user had responded with R to the question RESULT, MATRIX, OR END. A negative response (N) returns control to the main program.

DESCRIPTION OF OUTPUT

The following is a brief description of the output of each subroutine.

Maintenance	Verification of specific changes made to the matrix elements.
Run	Results of each run of the model stored in an existing disk file. These results will be overwritten by each subsequent run until the user specifies a different file for storage of the results.

Print	All or a portion of the results of a run of the model and the current contents of the subpopulation matrices. These are displayed in tabular form and columns corresponding to different paygrades. Results are shown as two superimposed matrices with state values immediately above qnd slightly to the left of loss values.

Refer to Figures 5 and 6 for examples of possible output. Figure 5 provides the printout for the AFSC with summed YOS of the total for the data printed in Figure 4 (year 1977). Figure 6 is a printout of the TI (Transfer-In) matrix for the same AFSC.

```
RESULT, MATRIX, OR END (R, M, OR E) ?R
PAYGRADES ? ALL
YEARS OF SERVICE ?  COL
PROJECTION YEARS ?  1.10

COLLAPSED BY YCS:
-----------------

YEAR  1975
PAYGRADE:    3       4       5       6       7       8       9

STATE:      807     891     537     382     134      6       0
 LOSSES:       147     307      46      48      38       2       0

YEAR  1976
PAYGRADE:    3       4       5       6       7       8       9

STATE:      442     954     573     319      89      6       0
 LOSSES:        71     256      32      34      15       2       0

YEAR  1977
PAYGRADE:    3       4       5       6       7       8       9

STATE:      251     947     583     296      80      7       0
 LOSSES:        45     198      32      37      21       2       0

YEAR  1978
PAYGRADE:    3       4       5       6       7       8       9

STATE:      279     872     602     278      60      7       0
 LOSSES:        40     137      37      15      12       2       0

YEAR  1979
PAYGRADE:    3       4       5       6       7       8       9

STATE:      279     857     609     285      56      7       0
 LOSSES:        40     171      39      24      12       2       0

YEAR  1980
PAYGRADE:    3       4       5       6       7       8       9

STATE:      279     843     598     293      57      7       0
 LOSSES:        40     166      34      27      13       2       0

YEAR  1981
PAYGRADE:    3       4       5       6       7       8       9

STATE:      279     837     575     291      59      7       0
 LOSSES:        40     153      28      26      13       2       0

YEAR  1982
PAYGRADE:    3       4       5       6       7       8       9

STATE:      279     837     550     293      54      7       0
 LOSSES:        40     164      27      23      12       2       0

YEAR  1983
PAYGRADE:    3       4       5       6       7       8       9

STATE:      279     835     528     300      62      7       0
 LOSSES:        40     165      26      21      11       2       0

YEAR  1984
PAYGRADE:    3       4       5       6       7       8       9

STATE:      279     834     524     314      55      7       0
 LOSSES:        40     165      24      14       9       2       0
```

Figure 5 - Result matrix - summed years of service.

```
RESULT, MATRIX, OR END (R,M, OR E)  ?M

MATRIX NAME ?  TI


TI MATRIX:

PAYGRADE:   3      4      5      6      7      8      9

YOS= 1    252      0      0      0      0      0      0
YOS= 2      7      0      0      0      0      0      0
YOS= 3      7      5      0      0      0      0      0
YOS= 4      0     18      0      0      0      0      0
YOS= 5      0     16      1      0      0      0      0
YOS= 6      0      3      6      0      0      0      0
YOS= 7      0      2      2      0      0      0      0
YOS= 8      0      0      2      0      0      0      0
YOS= 9      0      0      4      0      0      0      0
YOS=10      0      0      7      0      0      0      0
YOS=11      0      0      2      0      0      0      0
YOS=12      0      0      1      0      0      0      0
YOS=13      0      0      0      0      0      0      0
YOS=14      0      0      3      0      0      0      0
YOS=15      0      0      1      1      0      0      0
YOS=16      0      0      0      1      4      0      0
YOS=17      0      0      0      1      2      0      0
YOS=18      0      0      0      0      1      0      0
YOS=19      0      0      0      1      3      0      0
YOS=20      0      0      0      0      2      0      0
YOS=21      0      0      0      0     11      7      0
```

Figure 6 - TI (Transfer-In) matrix.

REFERENCES

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Goclowski, J. C., Peskoe, S. E., LoFaso, A. J., Vaughan, J., & Baran, H. A. *Air Force personnel availability analysis: Application techniques of the Personnel Availability Model (PAM).* AFHRL-TR-79-67. Wright-Patterson AFB, OH: Advanced Systems Division, Air Force Human Resources Laboratory, 1980.

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APPENDIX A - A SAMPLE PAM ANALYSIS OF AIR FORCE PERSONNEL

A sample PAM analysis was made of personnel in several selected Air Force Specialty Codes (AFSCs) to demonstrate use of the model as a research tool for projecting the future availability of HR to support a new weapon system. In addition, special subpopulations were identified and their future availability was projected to demonstrate some of the important features of the model.

Fifteen (15) projections were addressed with each projection specified for the years 1975-1976. (The year 1975 was used as the baseline from which the projections were made.) The 15 projections are an aggregate population of 13 AFSCs (325x0, 325x1, 328x0, 328x1, 328x4, 423x0, 431x1E, 431x1C, 423x1, 423x3, 423x4, 426x2, 531x3); and a 14th pseudo-AFSC called "external" which was used to account for state transitions between the total Air Force and the 13 AFSCs considered here. Each PAM projection consisted of actual population state matrices for the years 1975 and 1976 which were derived from Uniform Airman Record (UAR) files and estimated state matrices for the years 1977-1984, 1990, 1995, and 2000. For the purpose of analyzing the projection results, an equilibrium state matrix was computed for each of the populations projected. This matrix consists of the state populations that would ultimately exist if the projection process were carried to a steady state.

The results illustrate two key features of the PAM.

1. The ability of the model to select any population that can be defined by UAR field values and determine the transition statistics for that population.

2. The ability of the model to account for deficiencies in the input data by allowing the user to modify model parameters computed from the data

In the example that follows, three populations of decreasing size were projected in equilibrium.

Grades	3	4	5	6	7	8	9
ALL AFSC							
1975	25305	20543	17640	9952	3424	305	16
Equilibrium	19413	28041	18441	11591	4128	424	27
AFSC 423x4							
1975	800	891	597	337	63	1	0
Equilibrium	782	1571	671	340	41	0	0
AFSC 423x4/C-130							
1975	36	41	48	24	3	0	0
Equilibrium	12	19	9	0	0	0	0

For the third population (423x4/C-130) the sample size is too small to produce realistic transition probability matrices. Several of the states in the 1975 423x4/C-130 state matrix are void or contain fewer than five airmen. When this situation arises, transition probabilities are constrained by the data in the form:

m/n (where $m = 0,1,2,\ldots, n$ and $n = 1,2,3,4,5$)

In actuality, any number between 0 and 1 can be a reasonable transition probability. As a rule, if each non-zero element of the inital state matrix is greater than 25, there is at least a 90 percent chance that the estimated transition probability is within ±.15 of the true transition probability. Greater accuracy in the estimate requires a large sample size, while a less stringent accuracy requirement allows the use of a smaller sample size. The 423x4/C-130 population clearly does not satisfy this rule.

The PAM provides an override feature which allows the user to make accurate projections when dealing with a small data sample. This feature allows the user to alter the initial state matrix, the recruitment matrix, or any of the transition probability matrices prior to making a projection. Its use is illustrated by the projections of the 423x4/C-130 population. One state for this population (Years of Service = 2, Paygrade = 4) was empty in 1975, and as a result, transition probabilities for this state could not be estimated from the data. Therefore, user-specified transition probabilities were assigned to this state. (Note that although this allows the model to be used with more precision, the accuracy of the results are determined by a user's prior knowledge of these transitions.) After setting the increment probability for this state equal to 1, the following revised projection was obtained.

Grade	3	4	5	6	7	8	9
423x4/C-130							
1975	36	41	48	24	3	0	0
Steady state	12	47	32	7	0	0	0

Another method of applying the override feature to avoid parameter estimation problems associated with small subpopulations is to make projections of using the transition probability matrices as computed from a larger, but characteristically similar population. The logit and discriminant analysis techniques may be used to determine if the large and small populations are jointly homogeneous. If they are, the transition probabilities of the larger population may be used. This approach was applied in the HR requirement/HR availability comparison described in this appendix.

The remainder of this appendix is divided into three sections. They are outlined as:

1. Projection Results Employing Projective Capability Improvement Techniques
2. Using the PAM for Human Resource Requirement/Availability Comparisons
    - Generating Human Resource Requirements
    - Projecting Human Resource Availability
    - Making Human Resource Requirement/Availability Comparisons
3. Results

PROJECTION RESULTS EMPLOYING PROJECTIVE CAPABILITY IMPROVEMENT TECHNIQUES

Technical report AFHRL-TR-79-67 discusses the identification of homogeneous subpopulations. Driving attributes were introduced as variables that correlate highly with nonuniform transition rates to discriminate among the homogeneous subpopulations.

A categorical analysis (the analysis of transition frequencies across attributes) indicated that AFSC should be considered a driving attribute. This implies that projections should be made on a by-AFSC basis, rather than across AFSCs. However, no other attributes were identified by this process that would pass the statistical significance tests discussed in AFHRL-TR-79-67. Therefore, more powerful regression techniques were applied in an effort to determine additional driving attributes.

An attempt was made to identify, by logit analysis, the driving attributes for a sample Air Force population. The sample chosen consisted of 3,314 first-term enlistees in tah 328xx AFSC. Logit analysis was used to determine which attributes were most important when trying to explain individual losses of first-term airmen from the Air Force. Table A-1 lists the variables used in the analysis, the average values of these variables for all 3,314 airmen, the group averages of the 2,641 airmen that remained in the Air Force, and the group averages of the 673 that were counted as losses in 1975.

Table A1 shows that the descriptive statistics for the retained and lost airmen are quite similar apparently because the selection of AFSC 328xx presupposes high Armed Services Vocational Aptitude Battery (ASVAB) and Armed Forces Qualification Test (AFQT) composite scores, and the choice of first-term enlistees ensures a small range of age and years of service (YOS). Variables which are important because of their relative values for retained and lost airmen are: skill level, grade, YOS, marital status, number of dependents, and (to a lesser degree) the administrative test score.

Table A1 – Data Summary for AFSC 328xx First Enlistments (1975).

Variable	Average/Percentage		
	All	Retentions	Losses
Skill level	2.84	2.82	2.93
Years of schooling (beyond eighth grade)	4.23	4.23	4.24
Grade	3.51	3.45	3.74
Years of service	2.96	2.83	3.44
Age	21.7	21.6	22.1
Sex			
Male	94%	94%	96%
Female	6%	6%	4%
Marital status			
Single	51%	50%	56%
Married	47%	48%	42%
Divorced, widowed, separated	2%	2%	2%
Number of dependents	.76	.78	.70
Race			
White	94%	94%	97%
Black	4%	5%	3%
Other	1%	1%	1%
Test scores (percentile)			
Administrative	71.9	71.3	74.1
Electrical	90.5	90.4	91.2
General	82.1	82.1	81.9
Mechanical	80.0	79.6	81.3
AFQT	82.5	82.4	83.1
Number of Airmen	3314	2641	673

Logit analysis, as described in AFHRL-TR-79-67, was conducted on four randomly selected 10 percent samples of this population with the following regression equation results.

Example	LOGIT EQUATION
1	$Z = -1.43 - .94\ (SCHOOL) + 1.40(YOS) = 1.30(MH)$
2	$Z = 05.06 + 1.23(YOS) = .80(MH)$
3	$Z = -.71 - 1.39(SKILL) + 1.28(YOS) = 1.57(MH)$
4	$Z = -4.41 + 1.10(YOS) = 1.12(MH)$

To understand the examples above, descriptions of the operands are:

Z	*The logit of the loss probability.* Z = "ln" [P (loss)/(1-P (loss))] If Z 0 for an airman, it is expected that the airman will leave the Air Force in the next year.
SCHOOL	The number of years of schooling beyond the eighth grade.
YOS	Years of service.
MH	This value is 1 if an airman was married but not divorced, *separated, and so forth; otherwise it is 0.*

The fact that logit (probability of loss) is equal to Z implies that the probability of loss is:

$$P(loss) = \frac{e^Z}{1 + e^Z}$$

Note that P(loss) increases as Z increases, and decreases as Z decreases. Therefore, the regression equations may be interpreted as follows.

> Any variable with a positive coefficient has a positive effect on loss probability. Thus, first-term enlistees with high YOS are more likely to leave the Air Force. Airmen who are married or who have high skill or school levels tend to remain. The negative constant in the equations indicates that Z has a negative bias because the majority of the sample stayed in the Air Force.

Table A2 provides the loss probability evaluated at the group centroids (from Table A1) for each logit equation. According to this calculation, the average airman that left *the* Air Force in *1975 is* more likely to remain in the Air Force than leave. This indicates that the logit equations will not discriminate completely between those airmen that leave and those who stay.

Table A2 - P (loss) Evaluated at Group Centroids for AFSC 328xx First Enlistments.

		Group	
Logit Equation	All	Retained	Lost
1	.13	.11	.24
2	.14	.12	.24
3	.17	.15	.26
4	.16	.14	.25

Further analysis indicates that system constraints tend to prevent airmen from leaving until their fourth year. Thus, YOS appears to be the driving attribute as expected because YOS 4 is a high loss year.

Marital status also appears as a driving attribute. Because marital status does not necessarily correlate with YOS, nor is it monotonic as are skill level and grade, this attribute was further analyzed. The AFSC 328x0 population was divided into two subpopulations using *marital status*. (Recall that the only other driving attribute that has been identified is AFSC. By choosing only the 328x0 personnel, the entire population already was divided into two groups--328x0 and others.) The two subpopulations are (a) airmen who were married and, (b) airmen who, in 1975, were single, widowed, divorced, or legally separated. These subpoulations were projected separately and then summed together to achieve the total force strength of AFSC 328x0. The results of this approach are summarized below.

Population	1975	Equilibrium
(1) 328x0	2249	3968
(2) 328x0 (married)	717	1587
(3) 328x0 (other)	1532	793
(4) Summed (2) + (3)	2249	2380

Note that equilibrium state of population 4 (the sum of populations 2 and 3) is substantially different from the 328x0 equilibrium population. It is not possible to identify the more accurate projection without data from the next year, 1977. If such data were available, the projection could be checked against the actual state matrices for the outyear in question as the basis for a determination of relative accuracy. However, the above results do show that more detailed study of the effects of marital status on service tenure may lead to more accurate projections for this subpopulation.

Based on the fact that no significant driving attribute was discovered, it is apparent that the AFSC 423xx subpopulations are basically homogeneous with respect to the attributes considered.

Thus, it may be concluded that no significant driving attributes will likely distinguish between subpopulations composed of personnel with technical AFSCs. This conclusion is reasonable because technical AFSCs are selected on the basis of ASVAB scores and technical aptitude. Of course, it is likely that some other driving attributes would surface if the entire Air Force population (both technical and non-technical AFSCs) were examined.

USING THE PAM FOR HUMAN RESOURCE REQUIREMENT/ AVAILABILITY COMPARISONS

The new weapon sytem selected for human resource requirement/ availability comparisons was the Advanced Medium Short Takeoff and Landing (STOL) Transport (AMST). This section contains an example of the PAM application during the design phase of weapon system acquisition. It includes an explanation of how the theoretical HR requirement for the AMST was derived, a discussion of the HR availability projection, and the results of the HR requirement/availability projection comparisons. The section is divided into three subsections. They are Generating Human Resource Requirements, Projecting Human Resource Availability, and Making Human Resource Requirement/ Availability Comparisons.

Generating Human Resource Requirements

Utilizing Maintenance Action Networks for an AMST-like weapon system and the Reliability and Maintainability (R&M) Model*, estimates of the required maintenance manhours (MMH) per 1000 flight-hours (KFH) were made for each AFSC involved in avionics and/or landing gear maintenance for the weapon system. From these values, the number of airmen in each AFSC required to support a squadron of AMST-like aircraft was determined with the equation:

$$\text{No. Men} = \frac{(\text{MMH/KFH})\ (\text{FH/SQ-YR})\ (\text{YR/12 MON})}{(\text{Efficiency Factor})\ (\text{Workdays/month})\ (\text{Shift hours/day})}$$

The following operand values used in the equation represent a hypothetical peacetime scenario for an AMST-like aircraft and mission.

FH/SQ-YR = (1.8 hours/aircraft-day) (5 days/wk) (52 wks/year)
Efficiency factor = .6
Workdays/Month = (5 days/week) (4.33 wks/month)
Shift hours/Day = 8

Therefore, with the given values, the number of men per squadron is equal to .006 (MMH/KFH) for each AFSC.

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*AFHRL-TR-78-2(I), Digital Avionics Information System (DAIS): Reliability and Maintainability Model.

At full deployment (1988) of the new weapon system (based on Air Force plans current in 1978) it was postulated that there would be 16 squadrons of aircraft. Therefore, for 1988, the HR requirement per AFSC for the entire fleet would be .08 (MMH/KFH), as calculated with the above equation. The MMH estimates for each AFSC are derived from the R&M model. Table A3 shows the 1988 HR requirement.

Table A3 - 1988 HR Requirement for the AMST Fleet.

AFSC	Title	HR Requirement (number of men)
32830	Avionics Communication	144
32850		288
32831	Avionics Navigation	144
32851		176
32834	Inertial and Radar Navigation	64
32854		64
42330	Aircraft Electronic Systems	32
42350		48
42334	Aircraft Pneudraulics	16
42354		48
43131	Aircraft Maintenance	32
43151		64
53153	Airframe Repair	16
Total HR Requirement		1136

Projecting Human Resource Availability

It was assumed that C-130 maintenance personnel would eventually be the support personnel for the new AMST weapon system. Therefore, the subpopulation extracted from the data base to make the HR availability projections consisted of airmen with the C-130 Special Experience Identifier (SEID) in 1975. As indicated earlier in this report, few were found. It appears that many C-130 airmen lack the C-130 SEID; hence, a lower number were identified in the screening process than might reasonably be expected.

In an alternative attempt to identify airmen with the C-130 SEID, a figure was obtained for the total personnel assignment. To at least approximate the number of personnel actually assigned to the C-130 in 1975, that number of the total personnel assignment was used in combination with a best estimate of the C-130 AFSC assignment to scale the extracted subpopulation.

The 1975 C-130 population was derived from a UDL manpower list for the 314th TAW LRAFB, a 96-aircraft wing of C-130s. There were approximately 710 C-130s in operation in 1975; so, the 328x4 manpower list was scaled upward by a factor of 710/96, resulting in the 1975 C-130 state matrix depicted in Table A4. The only AFSCs which contained C-130 SEIDs in quantities large enough for accurate projection were the 328x4, 423,4, and 426x2. This was considered satisfactory because the theoretical HR requirement derived in the previous subsection is for avionics and landing gear maintenance which included the 328x4 and 423x4 AFSCs. Hence, the HR requirement/availability comparison became the HR requirement for 328x4 and 423x4 in 1988 compared to their HR availability projections based on a scaling of the 1975 data base. The following discussion relates to the 328x4/C-130 population. AFSC 423x4 for the C-130 was discussed earlier in this report.

Table A4 - 328x4/C-130 Scaled State Matrix for 1975.

PAYGRADE:	3	4	5	6	7
YOS = 1	55	0	0	0	
2	12	0	0	0	
3	7	23	0	0	
4	0	32	0	0	
5	0	13	2	0	--
6	0	2	0	0	
7	0	2	6	0	
8	0	0	2	0	
9	0	0	5	0	--
10	0	2	6	0	
11	0	0	16	2	
12	0	0	0	2	
13	0	0	2	--	

As shown in Table A4, the 328x4/C-130 state matrix is sparse. Therefore, the computation of transition probabilities falls victim to the small numbers discussed in AFHRL-TR-79-67. However, statistical analysis of the transition rates for this subpopulation and the complete 328x4 population indicated that the SEID was not a driving attribute. The transition probability matrices computed for the full 328x4 were therefore used to make the 1988 projections. The transfer-in matrix (which contains the recruits newly assigned to this AFSC) was further modified so that there would be 23 recruits into YOS 1, paygrade 3 in each projection year. This number of recruits was selected because there were 23 losses from paygrade 3 in 1976. Table A5 shows the 1988 HR availability projection of the 328x4/C-130 subpopulation.

Table A5 - 328x4/C-130 Projection to 1988.

PAYGRADE:	3	4	5	6	7
YOS = 1	23	0	0	0	0
2	24	0	0	0	0
3	13	7	0	0	0
4	0	23	0	0	0
5	0	14	1	0	0
6	0	14	1	0	0
7	0	0	0	0	0
8	0	0	2	0	0
9	0	0	0	2	0
10	0	0	1	0	0
11	0	0	2	0	0
12	0	0	1	0	0
13		.			
		.			
		.			

Making Human Resource Requirement/Availability Comparisons

The hypothetical requirement of AFSC 328x4 for the AMST-like aircraft is 128 airmen distributed evenly between the 3 and 5 skill levels. The 328x4/C-130 HR availability is expected to be 60 airmen in paygrade 3, 58 airmen in paygrade 4, and 8 airmen in paygrade 5. Assuming that the E-4s will be operating in skill level 5 duties, the HR requirement is almost exactly met; that is, the projected HR availability is sufficient to satisfy the HR requirement. In addition, a comparison of the 423x4/C-130 projection with the HR requirement in Table A1 indicates more than enough aircraft pneudraulics mechanics to support the weapon system at full-deployment.

Therefore, with the implementation of a recruitment policy to recoup expected losses from paygrade 3, the PAM projections indicate that no further changes in the status quo are necessary to meet the 1988 HR requirements for the AMST weapon system.

RESULTS

In summary, separate human resource availability projections were conducted for years 1977-1984, 1990, 1995, and 2000. Each of the projections involved 13 selected maintenance AFSCs. Each projection was accomplished using the airmen transition probabilities generated for the 1975-1976 baseline years.

In the search for driving attributes, the categorical analysis indicated that sufficient differences exist among the transition rates across AFSCs. This makes it necessary to project HR availability within AFSCs rather than across AFSCs. No variables were found to be driving attributes within the technical AFSCs examined in this study, and it can be concluded that probably none would be found within any other technical AFSCs.

Logit analysis was then applied to several subpopulations within AFSCs. Marital status appeared as a critical variable in the loss rates among AFSC 328xx first-term enlistees. Other attributes were identified for different combinations of subpopulations and transitions, but no variable appeared as a driving attribute across a full AFSC. In general, this implies that an AFSC may be considered a homogeneous subpopulation for projection relative to those attributes considered. Thus, for the technical AFSCs under consideration, the PAM projections will reflect the information in the data with sufficient accuracy.

The projection and data base maintenance capabilities of the PAM were demonstrated by the example comparison of a theoretical full deployment (1988) HR requirement of AFSC 328x4 for an AMST-like aircraft to the projected HR availability for 328x4 airmen with C-130 experience using 1975 data as a baseline. Parameter estimation errors due to inadequate size of populations were encountered in projecting tahe 328x4/C-130 subpopulation. However, statistical analyses incorporated as part of the application methodology indicated that because the whole 328x4 population was similar enough to the 328x4/C-130 subpopulation in terms of transition rates across the special experience identifier, use of the parameters estimated from the larger population for the projection of the C-130 extraction was valid. The data base maintenance features were used to make this substitution, as well as a change in the recruitment policy. Projections of the modified data base were then made.

It was found that the 1988 HR requirement and HR availability were in close agreement. That is, the 1988 requirement for 328x4 personnel to support the new weapon system can be expected to be filled by the current Air Force personnel inventories and policies, provided there is sufficient recruitment to recoup annual losses from paygrade 3.

In summary, this application of the PAM has demonstrated how projections of future force strength may be made and subsequently applied to the problem of personnel planning.

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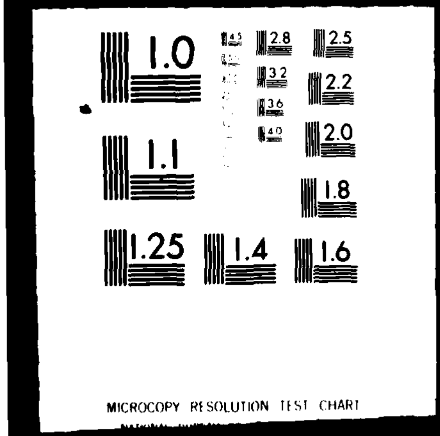

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ERRATA

AFHRL-TR-79-68 AIR FORCE PERSONNEL AVAILABILITY ANALYSIS: PROGRAM DESCRIPTION FOR THE PERSONNEL AVAILABILITY MODEL (PAM)

On page 22, under Listing I at top of page, delete 13 items under JCL (from "100-DRO . . . " through "220=+EOF") and add the entries shown on the attached sheet.

E. L. ELLIOTT
Chief, Technical Editing

ATTACHMENT FOR AFHRL-TR-79-68 ERRATA SHEET

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ABC,T500,I0400,MT1. User Number, Header
COBOL5.
FTN5,ANSI=0.
LABEL,TAPE1,R,L=$PAMRECS$,VSN=L02560,NORING,D=HY.
ATTACH,TAPE2,SELREC.
ATTACH,TAPE3,PAM2DAT.
REQUEST,TAPE4,*PF.
REQUEST,TAPE10,*PF.
REQUEST,TAPE30,*PF.
REDUCE.
LGO.
CATALOG,TAPE4,DEF4,RP=30.
CATALOG,TAPE10,GHI10,RP=30.
CATALOG,TAPE30,JKL30,RP=30.
*EOR.
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NOTES:

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   ABC - Site ID, as provided by WPAFB computer center.

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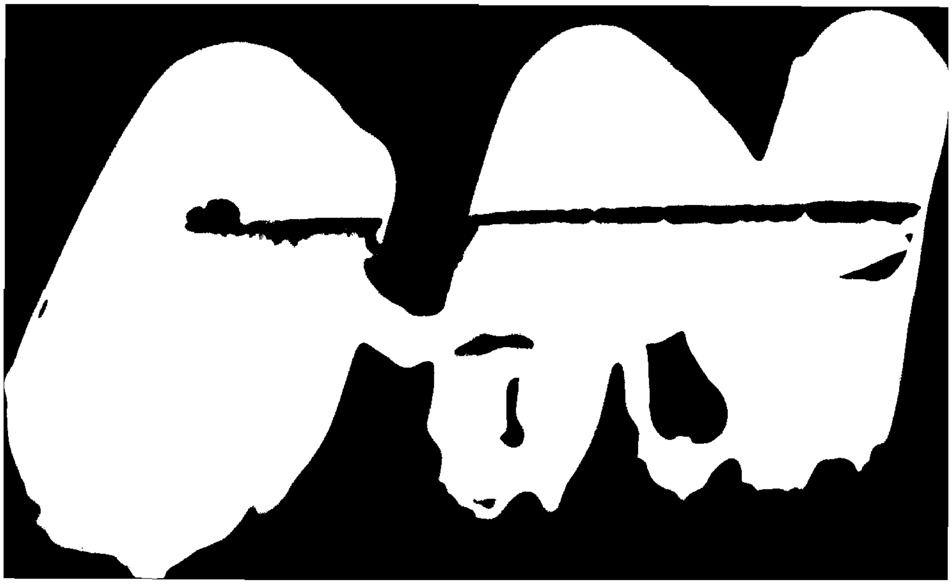
   DEF4,GHI10,JKL30 - Local file names for storage of output. Any usable file name will suffice.

   RP=30 - Length of time local files are to be retained in storage. 30 equals 30 days storage; default value is 8 days.



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Errata

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16 JAN 1981

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FOR THE COMMANDER

Wendell L Anderson

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