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TABLE COMPUTATION PROGRAM: USERS MANUAL(U) AIR FORCE
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**HUMAN
RESOURCES**

**TABLE COMPUTATION PROGRAM:
USERS MANUAL**

By

Thomas A. Boynton, Major, USAF

**ANALYSIS AND EVALUATION OFFICE
HQ Air Force Human Resources Laboratory
Brooks Air Force Base, Texas 78235**

April 1983

Final Technical Paper

Approved for public release; distribution unlimited.

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This paper has been reviewed and is approved for publication.

ROBERT A. BOTTENBERG, Director
Analysis and Evaluation Office

RONALD W. TERRY, Colonel, USAF
Commander

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER AFHRL-TP-82-41	2. GOVT ACCESSION NO. AD-A128	3. RECIPIENT'S CATALOG NUMBER 268
4. TITLE (and Subtitle) TABLE COMPUTATION PROGRAM: USERS MANUAL		5. TYPE OF REPORT & PERIOD COVERED Final --
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Thomas A. Boynton		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Analysis and Evaluation Office HQ Air Force Human Resources Laboratory Brooks Air Force Base, Texas 78235		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 99830999
11. CONTROLLING OFFICE NAME AND ADDRESS HQ Air Force Human Resources Laboratory (AFSC) Brooks Air Force Base, Texas 78235		12. REPORT DATE April 1983
		13. NUMBER OF PAGES 22
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS (of this report) Unclassified
		15.a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited.		
17. DISTRIBUTION STATEMENT (of this abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) benefit/cost analysis discounting interactive table manipulation numerical presentation sequences statistics tables <i>This document</i>		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This technical paper describes the Table Computation Program (TCP) developed to facilitate the manipulation and presentation of tabular information for analysis and analysis reporting purposes. It includes an overview of how the program functions and instructions on how to use it. In addition, technical information is provided for those who may wish to modify or expand the program to satisfy unique requirements.		

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HQ Air Force Human Resources Laboratory
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Reviewed and submitted for publication by

**Robert A. Bottenberg
Director
Analysis and Evaluation Office**

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TABLE COMPUTATION PROGRAM (TCP)

I. INTRODUCTION

The purpose of the Table Computation Program (TCP) is to provide an interactive, flexible tool for creating, modifying, and manipulating tabular information. The need for a TCP arose in the Air Force Human Resources Laboratory (AFHRL) Office of Analysis and Evaluation. This office has been responsible for estimating costs and benefits associated with many of the AFHRL research and development (R&D) subthrust components. Actual annual costs and benefits are discounted and summed. These results are then multiplied by probabilities that reflect the likelihood that those discounted benefits will occur. In the past these tabular operations were performed manually at a great cost in time. Additionally, once a table was completed, changes in the analysis or the answering of "what if" questions required a complete manual reworking of the table. Each table was somewhat unique in its characteristics, and so a special purpose program designed to automate the process for one table would not likely be useful for many of the others.

An analysis of the tabular manipulations required to produce many of the cost/benefit analysis report tables already in existence showed that the following set of columnar operations was both necessary and sufficient to produce all but a few highly specialized tables.

1. Input a column of values.
2. Generate a sequence of fiscal year labels.
3. Generate a column of discount factors.
4. Multiply the elements in one column by the corresponding elements in another column to form a third column.
5. Edit the contents of a column.
6. Calculate the sums of columns.
7. Output the results with column and table headings.

These capabilities have been generalized, expanded, and incorporated into the TCP. A modular program structure has been maintained to facilitate future expansion of the TCP capability. In addition, a capability has been provided to store all results in disk files named by the user for future recall, thus eliminating the need to rebuild the table if, at some later date, there is a desire to modify certain table characteristics in order to answer "what if" questions.

The emphasis throughout has been to provide a user friendly implementation and integration of many straightforward but tedious manual operations. The result is that tables which initially took approximately 45 minutes to create

manually now take less than 15 minutes. In addition, changes and recalculation of table values can be accomplished at a much greater savings in time. Avoidance of arithmetic errors which so easily occur in tedious computations provides added confidence that the results are free of non-systematic errors.

II. OVERVIEW OF PROGRAM OPERATION

The TCP has been programmed in the BASIC computer language. This language was chosen for several reasons. A program listing is contained in Volume 2.

1. BASIC is highly interactive and lends itself readily to the rapid creation of routines which may only be used a few times.
2. BASIC is an easy language to learn. It was expected that other analysts would find it convenient to write special purpose routines that could take advantage of the existing capabilities and modular format of the TCP.
3. The operations being performed by TCP are not highly iterative, and thus the added speed of a compiled language is not necessary.

The first 42 lines of code initialize the system, establish work space dimensions, and define three functions which are used to perform error trapping checks.

Lines 43 through 65 constitute the entire main program. The main program asks the user for a command. If the user supplies a valid command, the main program will select the subroutine corresponding to that command and transfer control to it. When the subroutine is done, the main program asks for another command. This continues until the command "EXIT" is given, at which point control is passed to the subroutine beginning at BASIC line 80000 which terminates program execution.

The remaining lines of the program are all subroutines. These subroutines begin on the BASIC line numbers indicated below:

<u>BASIC Line No.</u>	<u>Description of Subroutine</u>
1000	Input a column
2000	Add, subtract, multiply, or divide corresponding elements of two columns to form a third column
3000	Print selected columns (hard copy)
4000	Form a sequence of successive discounting factors
5000	Zero initialize a column. This is done whenever a column is created or overwritten
6000	Form an evenly spaced sequence of values (e.g., fiscal years)

<u>BASIC Line No.</u>	<u>Description of Subroutine</u>
7000	View selected columns on terminal
8000	Insert new elements into an existing column
9000	Delete elements from an existing column. Vacated elements past the new column end are set to zero
10000	Change (overwrite) selected elements of existing column
11000	Save all results to a file named by user
12000	Read previously saved results from a file specified by user
13000	Calculate a cumulative sum of selected columns
14000	Toggle the statistics printing enable switch on or off
15000	Change the heading of a specific column
16000	Specify the precision of numerical results
50000	Format multiple lines of column heading text
60000	Error messages
70000	HELP messages
80000	Terminate execution.
90000	Calculate statistics of a column. This is done whenever a column is created, changed, or overwritten.

III. HOW TO USE THE TABULATION COMPUTATION PROGRAM AT AFHRL

In the following discussion, non-underlined material represents a prompt printed by the computer.

Material which is underlined represents what the user's response should be to these prompts. It is assumed that the user has already signed on and that the system is waiting for instructions.

► @ADD NE*TCP.RUN

► TCP: ? ►

Immediately following the "TCP: ?" cue, the user will enter the appropriate command for the desired TCP function. The user who does not know any appropriate commands can enter "HELP," and will be told what to do. The user will continue using the TCP until done and will then type "EXIT" to terminate execution in a graceful manner.

IV. DESCRIPTION OF COMMANDS

A. General Description of Program Data Structure.

In order to use the TCP commands effectively, the user should have a general understanding of the simple data structure used by this program. The program uses a series of numbered columns as a work space. There are 80 columns, each of which can be up to 40 elements long. If you need fewer but longer columns, see Section V which explains how the program dimensions can easily be redefined. Which columns are used for any particular operation is totally under the control of the user. If the user chooses to place results in a column that contained previous information, the old information will be overwritten by the new results. Associated with each column is a variable (actually an element of an 80 element vector) for each of the following quantities:

1. Column Heading.
2. Column Length.
3. Column Sum.
4. Column Average.
5. Column Variance (unbiased sample variance).
6. Column Standard Deviation (square root of above variance).

Whenever the read (R) or write (W) commands are issued, the entire 80 X 40 work space with associated variables described above is read from, or written to, the specified file, regardless of how many columns or rows were actually used. Thus the user need not worry about what part of the work space to read or write.

B. Specific Commands.

In the following descriptions the mnemonic symbol appearing first is the command that will be recognized by the TCP program. Following the mnemonic symbol is a description of how that command works and what it does.

1. CC - Column by Column arithmetic. This command asks the user to specify a column, a rudimentary arithmetic operation (+, -, *, /), and a 2nd column. The order in which these two columns is specified is significant only if subtraction (-) or division (/) is specified. The user is then asked for the number of a column

in which to place the results and for a descriptive column heading. The results are obtained by performing the specified arithmetic operation between the *i*th element of the first and second specified columns, respectively, and placing the result in the *i*th element of the specified results column. This is done for all elements of the longest column. The shorter column is temporarily padded with zeroes to make it as long as the longer column. Thus, the results column will be as long as the longest column used. After the operation is completed, the length of the shorter column remains the same as it was prior to the operation.

2. CH - CHange elements in an existing column. When this command is given, the system will ask the user for the number of the column to be changed. It will then ask for the row number of the next element in that column to be changed. After the element number is specified, the system will print the current value of that element and ask for a response of 'Y', 'N', or 'D'. If 'Y' is specified (meaning YES), the system will ask for the new number. After the new number is entered, the system will print the next number and, again, ask for a response of 'Y', 'N', or 'D'. If 'N' (meaning NO), is entered, the system will ask for the row number of the next element to be changed. If 'D' is specified, the system will ask for another command.
3. CUM - This command allows the user to create a column with elements equal to the sum of all elements having a smaller or equal row number in each column of an arbitrary set of selected columns. In calculating this column, the negatives of specific selected columns may be used.
4. D - Delete elements from an existing column. This command behaves exactly the same way as the CH command except that elements are deleted rather than replaced. After an element is deleted, the system will allow deletion of subsequent elements until the bottom element has been deleted, at which point the system will allow deletion of the new bottom element until all elements have been deleted. Deletion of elements can be discontinued at any time the system requests a 'Y', 'N', or 'D' response by typing 'D'. Deletion of elements results in a column of shorter length.
5. DISC- DISCount factor generation. Use of this command will cause the system to ask the user for a discount rate. The user will next be asked to supply a column # and descriptive heading for the results. Finally the user will be asked to specify the number of years for which discount factors are required. Discount factors are then calculated for the specified number of years according to the formulas:

$$F(1) = (1 + (1/(1 + D/100))) / 2$$

and

$$F(i) = F(i-1) / (1 + D/100)$$

where

$F(i)$ is the discount factor for year i ,

and

D is the annual discount rate in percent.

The expression for $F(1)$ results in the calculation of midyear values for each factor in the series.

6. EXIT- This command terminates program execution, returning the user to the BASIC language system level. At this point the user can enter 'RUN' if more use of the TCP is desired. Otherwise the user should type 'BYE' to get back to the operating system level at which point '@FIN' should be entered to sign (
7. HC - Heading Change. This command allows the user to change the descriptive heading text for a selected column.
8. HELP- This command causes the system to list, on the terminal, each of the available commands, along with a brief description.
9. I - Insert elements into an existing column. This command behaves in exactly the same way as the IC command with the following exceptions. Elements will be inserted between existing elements of the specified column following the element number specified. Previously existing elements are not changed or overwritten.
10. IC - Insert Column. This command allows initial entry of tabular data from the terminal. The user is first asked for the number of the column into which data should be placed, and for a descriptive column heading. The user is then instructed to enter the data. After every value is entered, the system will respond with another question mark, at which point the user can enter another value, type 'D' to leave the entry mode, or type an 'R' followed by an integer valued number. When 'R' followed by an integer is entered (e.g., R5), the previously entered value will be repeated the number of times specified. For example if 23.4 is entered followed by an R5, the value of 23.4 will be automatically entered five more times. Thus the value 23.4 would appear six times in a row. If an 'R' is entered with no number, a repeat count of one is assumed.

11. PRINT-This command causes selected columns, with their associated headings to be output to the printer. Actual printing will not occur, however, until the command 'EXIT' is given. Each time the PRINT command is issued, the user is prompted for a descriptive table heading of up to 60 characters, and then is asked to specify how many columns should be printed. Up to eight columns will fit side by side on the printout without wraparound. If more than eight columns are specified for a single PRINT command, results may become difficult to read. After specifying how many columns are to be printed, the user is asked to specify which columns should be printed. Any numbered column can be printed in any position. The PRINT command can be issued any number of times during a single run. When the RUN is terminated by typing 'EXIT', a table, with its associated table heading, will be printed for each time the PRINT command was issued.
12. R - Read. This command causes the system to ask the user for the name of a file to be read. If the user does not provide the name of a file which was previously created using the W (write) command, an error message will result and execution will terminate. If a valid file name is given, the contents of that file will be read into the current work space and will be available for manipulation by any of the commands supported by TCP. Previously existing material in the work space will be overwritten.
13. SEQ - Sequence. This command allows the user to create a truncated sequence with equal intervals and store it in any desired column. There is no requirement that the sequence be either ascending or descending nor that the intervals be integer valued. The user is asked to supply a column #, descriptive heading, beginning value of the truncated sequence, ending value of the truncated sequence, and interval size. If the specified ending value of the truncated sequence falls between two members of the non-truncated sequence, the first member of the nontruncated sequence following that value becomes the ending value which the system uses to generate the truncated sequence. Sequence values are stored sequentially in the specified column. A common use for this command is to create a sequence of fiscal year labels which can later be printed along side other columns of the table to make the table easier to read and interpret.
14. SP - Set Precision. This command allows the user to specify the precision of numerical results to be displayed when using the PRINT or VIEW command.
15. TS - Toggle Statistics. Normally the only statistic that will be displayed for each column when the VIEW or PRINT commands are issued will be the column totals. If output of additional statistics is desired, issue the command TS. This will enable statistical output. Statistical output will continue to be enabled until the TS command is issued again.

16. VIEW- View selected columns at the terminal. This command works exactly the same way as PRINT, except that it allows the user to see results immediately at the terminal. This command does not produce hard copy unless the terminal is a printing terminal, in which case the result printed at the terminal is a hard copy. If using an 80-column-wide video terminal, only five columns can be viewed simultaneously without wraparound.

17. W - Write. This command works the same way as the read (R) command except that it causes work space contents to be saved on a user specified disk file. The file name must not exceed 12 characters in length nor contain an embedded period. A terminating period is optional. Violation of these rules may cause the program to terminate prematurely, thereby losing work space contents, perhaps before execution of a successful save can be accomplished. If the user specifies a file name which already exists, the contents of that file will be overwritten by the new material. During the process of adding information to the work space, it is always a good idea to issue the write command frequently so that if something does go wrong, only that information, added since the previous write command, will be lost.

C. Sample Session

In the sample session that follows, non-underlined material denotes prompts printed to the terminal by the computer. Underlined material denotes user response to program prompts. The session below assumes that the TCP has been invoked and is waiting for a command.

```

D TCP:? D SEQ
D COLUMN #? D 1
D HEADING? D FISCAL YEAR
D BEGINNING OF SEQUENCE? D 82
D END OF SEQUENCE? D 85
D INTERVAL SIZE? D 1
D
D TCP:? D DISC
D ENTER ANNUAL DISCOUNT RATE IN %? D 10
D COLUMN # FOR RESULTS? D 2
D HEADING? D DISCOUNT FACTORS
D NUMBER OF YEARS? D 4
D
D TCP:? D IC
D COLUMN #? D 3
D HEADING? D BENEFITS
D INPUT ENTRIES--"RN" FOR N REPEATS "D" WHEN DONE
D? D 23.4
D? D 97.5
D? D R2
D? D D

```

▶ TCP:? ▶ CC
 ▶ 1ST COLUMN #? ▶ 2
 ▶ OPERATION (+, -, *, /)? ▶ *
 ▶ 2ND COLUMN #? ▶ 3
 ▶ COLUMN # FOR RESULTS? ▶ 4
 ▶ HEADING FOR RESULTS? ▶ DISC BENEFITS

▶
 ▶ TCP: ▶ VIEW
 ▶ # COLUMNS YOU WANT TO VIEW? ▶ 4
 ▶ 1ST COLUMN #? ▶ 1
 ▶ 2ND COLUMN #? ▶ 2
 ▶ 3RD COLUMN #? ▶ 3
 ▶ 4TH COLUMN #? ▶ 4

▶ FISCAL YEAR	DISCOUNT FACTORS	BENEFITS	DISC BENEFITS
▶ 82	.95454545	23.4	22.336364
▶ 83	.86776859	97.5	84.607437
▶ 84	.78888054	97.5	76.915853
▶ 85	.71716413	97.5	69.923502
▶ TOTAL	TOTAL	TOTAL	TOTAL
▶ 334	3.3283587	315.9	253.78315

▶ TCP:? ▶ W
 ▶ OUTPUT FILE NAME (NO ELEMENTS)? ▶ TESTDATA

▶ TCP:? ▶ EXIT

▶ TIME: ▶ .757

▶ ▶ RUN

▶ TCP:? ▶ VIEW
 ▶ # COLUMNS YOU WANT TO VIEW? ▶ 4
 ▶ 1ST COLUMN #? ▶ 1
 ▶ 2ND COLUMN #? ▶ 2
 ▶ 3RD COLUMN #? ▶ 3
 ▶ 4TH COLUMN #? ▶ 4

▶ TOTAL	TOTAL	TOTAL	TOTAL
▶ 0	0	0	0

▶ TCP:? ▶ R
 ▶ INPUT FILE NAME (NO ELEMENTS)? ▶ TESTDATA

▶ TCP:? ▶ 1
 ▶ COLUMN? ▶ 3
 ▶ ELEMENT TO INSERT AFTER? ▶ 2
 ▶ 97.5 --THIS ONE 'Y' OR 'N'? ▶ Y
 ▶ ENTER INSERTS--'RN' FOR N REPEATS 'D' WHEN DONE

▶ ? ▶ 11.7

▶ ? ▶ R5

▶ ? ▶ D

▶ ?

▶ TCP:? ▶ VIEW

▶ # COLUMNS YOU WANT TO VIEW? ▶ 4

▶ 1ST COLUMN #? ▶ 1

▶ 2ND COLUMN #? ▶ 2

▶ 3RD COLUMN #? ▶ 3

▶ 4TH COLUMN #? ▶ 4

▶

FISCAL YEAR	DISCOUNT FACTORS	BENEFITS	DISC BENEFITS
82	.95454545	23.4	22.336364
83	.86776859	97.5	84.607437
84	.78888054	11.7	76.915853
85	.71716413	11.7	69.923502
0	0	11.7	0
0	0	11.7	0
0	0	11.7	0
0	0	11.7	0
0	0	97.5	0
0	0	97.5	0
TOTAL	TOTAL	TOTAL	TOTAL
334	3.3283587	386.09999	253.78315

▶

▶

▶ TCP:? ▶ EXIT

▶

▶ TIME: .762

▶

▶ >>BYE

▶ UNIVAC BASIC 09:12:34 25 AUG 82

▶

▶ @FIN

After the '@FIN' command is given, the UNIVAC SYSTEM will sign the user off and deactivate the terminal. If the command 'PRINT' was issued during any run, printed output results should appear in the computer center output bin within about 15 minutes of the time the 'EXIT' command was issued.

V. REDEFINING PROGRAM ARRAY DIMENSIONS

Due to the fact that the AFHRL Office of Analysis and Evaluation works with benefit periods which are generally less than 20 years, the program array dimensions have been set to allow for 80 columns and 40 rows (40 elements per column). Other users, however, may need fewer but longer columns. If so, it

is easy to redefine the array dimensions. Only four statements in the entire program need be modified. In BASIC line number 50, variable D8 should be set equal to the new desired number of columns. In BASIC line number 70, variable D9 should be set equal to the new desired number of rows. In BASIC line numbers 80 and 81, vector and array dimensions should be set to reflect the new values for D8 and D9 as shown in the comment on BASIC line numbers 75 and 76.

When redefining program dimensions, care must be taken to ensure that the product of D8 and D9 does not exceed approximately 3200. If it does, the program will not run. If this happens, the user should simply experiment with values which produce a smaller product until success is achieved.

Files written by the TCP with current dimension specifications cannot be read after the TCP has been re-dimensioned.

VI. ADDING ADDITIONAL CAPABILITIES

Due to modular design of the TCP, additional capabilities can be quickly and easily added. To do so, the user will simply write a subroutine to support the new capability and add an appropriate 'IF' statement, between BASIC line numbers 800 and 950, that will recognize the new command and invoke the new subroutine when that command is given. If the new subroutine is to be added to the user's copy of the TCP on a permanent basis, the user should also add an appropriate PRINT statement between BASIC line numbers 70180 and 70490 to describe the command when 'HELP' is invoked.

The AFHRL Office of Analysis and Evaluation anticipates expanding the TCP; therefore, other users should ensure that subroutines they add have BASIC line numbers that are completely contained within the range 30000-49999. It is also convenient to ensure that subroutines begin with a descriptive REMark at a BASIC line number that is an integral multiple of 1000. This facilitates easy reference to the subroutine.

Care must be taken when using subroutine variable names that have been marked with an asterisk (*) in section VII, Description of Program Variables. These variables contain work space values and parameters, values used by the main program, or other permanent parameters, and must not be changed indiscriminately. They should not be used to store temporary values nor should they be used as counters since this would overwrite work space results or change program parameters.

The Air Force Human Resources Laboratory Office of Analysis and Evaluation would greatly appreciate a copy and description of any useful subroutines that have been added to the TCP by other users. Direct such inputs to:

AFHRL/OA
Brooks AFB, Texas 78235

VII. DESCRIPTION OF PROGRAM VARIABLES

- * A(J) = Average of Column J
- * B = Beginning of sequence
- * C(J,e) = The eth element of column J

- C\$ = The variable used for temporary storage of string values
 D = Discount rate
 D1 = 1 + Discount rate
 * D8 = # of columns this program allows
 * D9 = # of rows per column this program allows
 * D(J) = Standard deviation of column J
 E = End of sequence or end position of header string
 * F = Flag set to 1 if a subroutine executed
 * F1 = Flag for checking numerics in function B
 * F2 = Flag to print statistics
 F(J) = Flag to indicate end found for column J header text
 G = Gap between adjacent elements of sequence
 H(J) = Number of lines needed for column J heading
 * H\$(J) = Heading for column J
 I, K, M, Y = Temporary counters for for-next loops etc.
 J = Pointer to current column
 L = Max column length
 L\$ = Temporary heading manipulation string
 M = Maximum number of reading print lines needed
 N = Number of columns to be viewed and number of rows in column
 * N(J) = Current # of elements in column J.
 O\$ = String variable to store operation.
 P1 and P2 = Pointers to two columns involved in an arithmetic operation.
 P(J) = Pointer to position in column J header
 P\$ = Temporary output print string
 Q\$ = Temporary output cumulative print string
 * R\$ = Input variable for operator response
 S2 = Sum of column elements squared used in computing variance
 * S(J) = Sum of column J
 * S\$(J) = Form string for numeric output of column J
 * U(J) = Variance of column J
 V(I) = Ith column to be viewed

VIII. DESCRIPTION OF THE SOFTWARE

- A. Program Name: Table Computation Program (TCP).
- B. Version Name: Since there is only one version of this program, the version name is identical to the program name above.
- C. Software Technical Description:

This program has been programmed in the BASIC computer language and implemented using the Sperry Univac Series 1100 UBASIC/BBASIC level 9R1 Basic interpreter. It requires 38 thousand 36 bit words of memory and makes use of operating system executive commands using the EXEC statement. Thus unique features of operating system must be taken into account when implementing this software on a different system. See Section II for an outline of the structure of this program.

IX. INSTRUCTIONS FOR REQUESTING COPIES

For more information regarding this program contact the Air Force Human Resources Laboratory (AFHRL), Office of Analysis and Evaluation (OA).

X. RELEASE INSTRUCTIONS

Software normally can be released, free of charge, to Federal, state and local government agencies upon approval by AFHRL/TS or higher headquarters. Requesting agencies should complete the Air Force Standard Statement of Terms and Conditions included in this document and forward the completed statement to AFHRL/TS, Brooks AFB, Texas 78235. The cover letter for the request should be prepared on agency letterhead and include the name, address, and phone number of a contact point. If software is to be transmitted in machine readable form, the requesting agency should be prepared to supply the blank magnetic tape reels.

STATEMENT OF TERMS AND CONDITIONS
RELEASE OF AIR FORCE-OWNED OR DEVELOPED COMPUTER SOFTWARE

DATE: _____

1. In accordance with the provisions of AFR 300-6, release of the following U.S. Air Force software package (computer programs, systems descriptions, and/or documentation) is requested:

2. The requested software package will be used for the following purposes:

Such use is projected to accrue benefit to the Government as follows:

3. I/we will be responsible for assuring that the software that we received will not be used for any purpose other than shown in paragraph 2 above; also, it will not be released to anyone without the prior approval of the Air Force. Further, the release of the requested software package will not result in competition with other software packages offered by commercial firms.

4. I/we guarantee that the provided software package, and/or any modified version thereof, will not be published for profit or in any manner offered for sale to the government; it will not be sold or given to any other activity or firm, without the prior written approval of the Air Force. If this software is modified or enhances using government funds, the Government owns the results, whether the software is the basis of, or incidental to a contract. The Government shall not pay a second time for this software or the enhanced/modified version thereof. The package may be used in contract with the Government but no charge may be made for its use.

5. The U.S. Air Force is neither liable nor responsible for maintenance, updating or correction of any errors in the software package provided.

6. I/we understand that no material subject to national defense security classification or proprietary right was intended to be released to us. I/we will report promptly the discovery of any material with such restrictions to the Air Force approving authority. I/we will follow all instructions concerning the use or return of such material in accordance with regulations applying to classified material, and will make no further study, use or copy such material subject to security or proprietary rights marking.

7. I/we understand that the software package received is intended for domestic use only. It will not be made available to foreign governments nor used in any contract with a foreign government.

Signature of Requestor

Signature of Air Force
Approving Authority

Name/Title of Requestor

Name/Title of Air Force
Approving Authority

Organization/Address

Organization/Location

City, State, and Zip Code