AD-A092 297 MEGATEK CORP SAN DIEGO CA F/G 20/14

INTEGRATED REFRACTIVE EFFECTS PREDICTION SYSTEM (IREPS): PROGRA--ETC(U)

JUL 80 H V HITNEY, E W PASAHOW, M E O'BRIAN N00123-78-C-0043

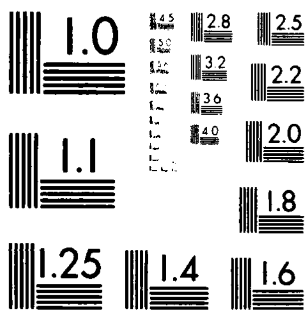
UNCLASSIFIED R2018-059-IF-2 NOSC-TD-365 NL

1 of 5

AD

A092 297

NOSC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

(12) LEVEL

NOSC

NOSC TD 365

NOSC TD 365

Technical Document 365

INTEGRATED REFRACTIVE EFFECTS PREDICTION SYSTEM (IREPS): PROGRAM PERFORMANCE SPECIFICATION

HV Hitney,
NOSC Technical Coordinator

EJ Pasahow and ME O'Brian,
Megatek Corporation

7 July 1980

Prepared for
Naval Air Systems Command

Approved for public release; distribution unlimited

NAVAL OCEAN SYSTEMS CENTER
SAN DIEGO, CALIFORNIA 92152

NAVAL OCEAN SYSTEMS CENTER, SAN DIEGO, CA 92152

AN ACTIVITY OF THE NAVAL MATERIAL COMMAND

SL GUILLE, CAPT, USN
Commander

HL BLOOD
Technical Director

ADMINISTRATIVE INFORMATION

Work was done under Program Element 63207N, Subproject WO512-CC by the Tropospheric Assessment Systems Branch. This document was produced for NOSC by Megatek Corporation, San Diego, California.

Released by
JH Richter, Head
EM Propagation Division

Under authority of
JD Hightower, Head
Environmental Sciences Department

(18) NOSC (19) TD-365

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: NOSC Technical Document 365 (TD 365)

2. GOVT ACCESSION NO.: AD-A092 297

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle): (6) INTEGRATED REFRACTIVE EFFECTS PREDICTION SYSTEM (IREPS): PROGRAM PERFORMANCE SPECIFICATION, Revision 2.01

5. TYPE OF REPORT & PERIOD COVERED: (9) Final Rept.,

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s): HV Hitney, NOSC Technical Coordinator; EJ Pasahow and ME O'Brian, Megatek Corporation (10) H. V. Hitney, E. W. Pasahow, M. E. O'Brian

8. CONTRACT OR GRANT NUMBER(s): (15) N00123-78-C-0043

9. PERFORMING ORGANIZATION NAME AND ADDRESS: Megatek Corporation, San Diego, CA 92106

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 63207N, W0512-CC

11. CONTROLLING OFFICE NAME AND ADDRESS: Naval Air Systems Command

12. REPORT DATE: (11) 7 July 1980

13. NUMBER OF PAGES: 410 (12) 412

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): Naval Ocean Systems Center, San Diego, CA 92152 (16) W0512...

15. SECURITY CLASS. (of this report): Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

(17) [illegible]

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

(14) R3411-017-IF-2

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Integrated Refractive Effects Prediction System (IREPS)
Computer programs
Electromagnetic wave propagation

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

IREPS assesses the refractive effects of the lower atmosphere for Naval electromagnetic systems operating above 100 MHz, including radar, uhf and microwave communications, electronic warfare, and missile guidance. This specification defines and specifies the computer program functions required by IREPS.

DD FORM 1473, 1 JAN 73 EDITION OF 1 NOV 65 IS OBSOLETE S/N 0102-LF-014-6601

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

391184

MEGATEK CORPORATION

FINAL REPORT

Title	:	Program Performance Specification for Integrated Refractive Effects Prediction System (IREPS), Revision 2.0
Number	:	R2018-059-IF-2
Contract No.	:	N00123-78-C-0043
NOSC Task	.	532-059
Date	:	7 July 1980

Submitted to:

Naval Ocean Systems Center
Code 5325
San Diego, California 92152

Accession For
NTIS GRA&I ☑
DTIC TAB ☐
Unannounced ☐
Justification

By
Distribution/
Availability Codes
Dist | Avail and/or Special
A

Prepared by:

E.J. Pasahow

M.E. O'Brian

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

SECTION 1

SCOPE

1.1 Purpose

The purpose of this specification is to define and specify the computer program functions necessary for the Integrated Refractive Effects Prediction System (IREPS) to give a comprehensive refractive effects assessment for Naval surveillance, communications, electronic warfare, and weapons guidance systems. IREPS is one of the programs in the Tactical Environment Support System (TESS) now under development by the Naval Air Systems Command (AIR-370) under program element 63207N, project W0512-CC. This document is written in accordance with the requirements of MIL-STD-1679(NAVY) and SECNAVINST 3560.1.

1.2 Mission

The primary mission of IREPS shall be to assess the refractive effects of the lower atmosphere for Naval electromagnetic (EM) systems operating at frequencies above 100 MHz. These systems include radar, UHF and microwave communications, electronic warfare, and missile guidance.

1.3 Scope

This specification establishes the functional and performance requirements necessary to design, develop, and test the IREPS computer program.

1.3.1 Identification

The digital processor program is the Integrated Refractive Effects Prediction System, abbreviated IREPS. This document specifically refers to IREPS revision 2.0, although many portions of the document apply to earlier IREPS revisions.

1.3.2 Functional Division

The computer program may be divided into fourteen groups of functions:

a. Auto-Mode
b. Coverage Display Generation (Cover)
c. Edit Libraries (Edit)
d. Environmental Data Input (Input)
e. Environmental Data List Generation (List)
f. ESM Range Table Generation (ESM)
g. Historical Refractive Effects Display Generation (Historical)
h. Initialize
i. Loss Display Generation (Loss)
j. Options Selection (Options)
k. Propagation Conditions Summary Generation (Summary)
l. Radiosonde Observation Analysis (RAOB)
m. Refractometer Data Input (Refractometer)
n. Surface Search Radar Range Table Generation (Surface Search)

In addition, a data base consisting of five libraries is required:

a. Electromagnetic System Parameters (System), containing both cover system data sets and loss system data sets.

b. Electronic Support Measure Receiver Intercept Ranges (ESM)

c. Environmental Data Sets (Environmental)

d. Historical Refractive Effects (Historical)

e. Surface Search Radar Ranges (Surface Search)

SECTION 2

APPLICABLE DOCUMENTS

2.1 Government Documents

Standards

MIL-STD-1679(NAVY)	Weapon System Software Development, 1 Dec 1978
SECNAVINST 3560.1	Tactical Digital Systems Documentation Standards, 8 Aug 1974

Other Publications

NOSC TD 238	Integrated Refractive Effects Prediction System (IREPS) Interim User's Manual, March 1979
NRL 7098	Machine Plotting of Radio/Radar Vertical Plane Coverage Diagram, 25 June 1970
US Navy Underwater Sound Laboratory TM 2141.2-75-68	Some Aspects of Signal Strength Variations for UHF Satellite Reception in a Sea Environment, 21 August 1968
NELC TR 1947	Propagation Modeling in the Evaporation Duct, 1 April 1975
NELC TN 3037	A Microwave Propagation Loss Program for a Standard Atmosphere, 9 September 1975
NOSC TN 669	Revised FNWC Radar Propagation Model, May 1979
NAVAIR 50-1D-4	Federal Meteorological Handbook, No. 4, Radiosonde Code
NAVAIR 50-1P-6	Air Weather Service Manual 105-10D

2.2 Non-Government Documents

Reports

MEGATEK R2018-011-IF-1	PROCAL IREPS, 1 Feb 1979
MEGATEK R2018-021-IF-1	Program Documentation "IREPS5" Draft, 15 June 1979
MEGATEK R2018-021-IF-2	Program Documentation, PROCAL E/WEPS Support
MEGATEK R2018-021-IF-3	PROCAL E/WEPS Support

Books and Journals

Ament, W.S., "Toward a Theory of Reflection by a Rough Surface," Proc. IRE, 41, No. 1, 142-146, Jan 1953.

Barrick, D.E., "Theory of HF and VHF Propagation Across the Rough Sea, 2, Application to HF and VHF Propagation Above the Sea," Radio Science, Vol 6, No. 5, May 1971.

Beard, C.I., "Coherent and Incoherent Scattering of Microwaves from the Ocean," IRE Transactions, Vol AP-9, September 1961.

Budden, K.G., The Waveguide Mode Theory of Wave Propagation, Prentice Hall, Englewood Cliffs, NJ, 1961.

Kerr, D.E., Propagation of Short Radio Waves, McGraw-Hill, New York, 1951.

Livingston, D.C., The Physics of Microwave Propagation, Prentice-Hall, Englewood Cliffs, NJ, 1970.

Reed, H.R. and C.M. Russell, Ultra High Frequency Propagation, Boston Technical Publishers, Cambridge, MA, 1966.

Yeh, L.P., "Simple Methods for Designing Troposcatter Circuits," IRE Transactions on Communications Systems, September 1960, Pg 193-198.

SECTION 3

TACTICAL DIGITAL SYSTEM REQUIREMENTS

3.1 General

The purpose of this section is to specify all functional, operational and performance requirements together with the design constraints and standards necessary to ensure proper development and maintenance of the IREPS program. Section 3.2 provides a general description of the IREPS program and identifies the program functions, peripheral equipment and interfaces. Section 3.3 gives an overview of the functions comprising the IREPS. Each function performed by the computer program is briefly described. Section 3.4 specifies the detailed performance requirements for each program function identified in the earlier discussions. Section 3.5 provides data base and system capacity requirements and relates them to required processor program storage requirements.

3.2 Program Description

This paragraph contains a general discussion of the IREPS computer system in which the program operates and the functions it must perform.

3.2.1 General Description

There are six key elements that need to be considered for a hardware system to host the IREPS software. These elements are listed below.

a. Computer

b. Mass storage device

c. Alphanumeric/graphic display

d. Hard copy unit

e. Operator keyboard

f. Cartridge magnetic tape unit

The requirements for each of these six elements are to some degree interrelated and any final selection of a host hardware system must trade off the various requirements to maximize overall capability. The requirements discussed below and in 3.2.2 are actually goals or targets that are based on the performance capabilities of the exploratory development system for IREPS and judgements as to what is actually needed to successfully perform the IREPS function.

The IREPS software is highly scientific in its nature and requires a computer system that easily and rapidly handles scientific calculations. It is also anticipated that the IREPS software will continue to be revised, which requires that a high level language compiler or interpreter be readily available for the computer. To size the computer, a small program has been devised that has approximately the same mix of calculations that are encountered in a typical IREPS coverage diagram calculation, exclusive of vector generation instructions. This program is shown in Figure 3.2.1-1 and is written in FORTRAN IV for the Data General Nova 800 system. Because the Data General exploratory development system is considered the minimum performance needed for the IREPS function, and the program in Figure

```
      DIMENSION RAR(100)
      PAUSE GO
      PIE=3.14159
      DO 240 J=1,100
      DO 220 I=1,100
      IF(50.LT.I.AND.I.LE.100) GOTO 190
      RAR(I)=I*5.34+PIE
      RAR(I)=(RAR(I)**2.4-12.1)/(RAR(I)+I)
      GOTO 220
  190 A=SIN(PIE*I/101.) + COS(PIE*I/202.) + TAN(PIE*I/303.)
      B=ATAN(PIE*I/123.)
      RAR(I)=SQRT(A*B) + ABS(EXP(I/50.)/(A-B))+I*20.
  220 CONTINUE
      TYPE J
  240 CONTINUE
      WRITE(10,9999) RAR
 9999 FORMAT(10(10(1X,F6.1)/))
      END
```

Figure 3.2.1-1

FORTRAN IV program for Data General Nova 800 system for benchmark timing of IREPS host computers.

3.2.1-1 takes 32.5 seconds to run on this system, a goal of 30-40 seconds to execute this benchmark program has been established. In addition, the computer should have at least 65K bytes of memory and the operating system should be able to overlay or chain programs residing on the mass storage device.

3.2.2 Peripheral Equipment Identification

Figure 3.2.2-1 is a block diagram for the IREPS system. Each of the peripheral equipment items is described below.

3.2.2.1 The Mass Storage Device

The IREPS program, data, and library files currently total less than 2 Megabytes and are expected not to exceed 4 Megabytes of storage in future revisions. The storage medium should be removable to facilitate program revisions, file updating, transportability, reliability, and security. There is no firm requirement that the mass storage device be a disk drive; however, access times and transfer rates should allow chaining or overlaying of programs at speeds of less than 10 seconds.

3.2.2.2 The Alphanumeric/Graphic Display

The display should present a minimum of 80 columns by 30 rows of alphanumeric characters and a minimum graphic resolution of 512 by 512 addressable and viewable points. Both graphics and alphanumerics must be presentable simultaneously. The graphics unit should be capable

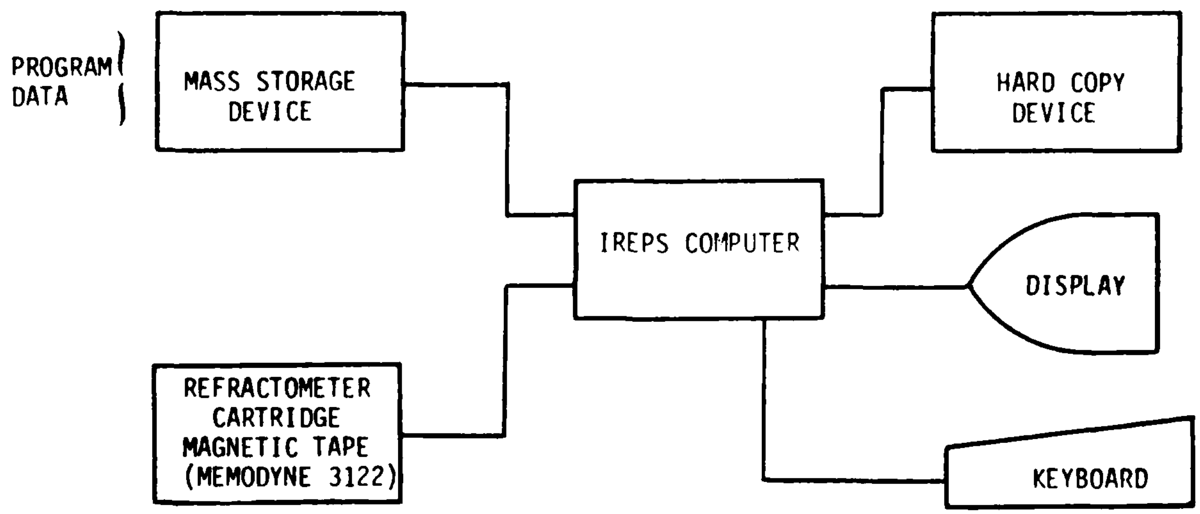


Figure 3.2.2-1. System Configuration

of generating and displaying 100 vector inches per second. The minimum viewable area of the display should be 8 inches (20.3 cm) horizontally and 6 inches (15.2 cm) vertically. The alphanumeric/graphic display could be a hard copy device, in which case a separate alphanumeric display would be required for operator prompting.

3.2.2.3 The Hard Copy Device

If the alphanumeric/graphics display is not itself a hard copy device, then a separate hard copy unit will be required. The hard copy device must provide the same resolution as the display and result in a hard copy of 8 1/2 by 11 inches (21.6 X 27.9 cm) that is amenable to normal duplication processes. Hard copies should be available within 30 seconds from time of request.

3.2.2.4 The Operator Keyboard

The keyboard must provide a minimum of the entire English language alphabet, the decimal digits 0 to 9, and the remaining grammatical, mathematical and control symbols of the USASCII character set. The keyboard should be of standard size and must be attached to the display in a manner such that the operator can monitor the display from the keyboard station.

3.2.2.5 The Cartridge Reader

The cartridge reader must be compatible with the AN/AMH-3 microwave refractometer. Therefore a Memodyne model 122 incremental cartridge magnetic tape reader or equivalent will be required.

3.2.3 Interface Identification

Not applicable.

3.3 Functional Description

This paragraph provides a functional description of the major program functions. Subparagraph 3.3.1 describes each equipment component which interacts with the program. Subparagraph 3.3.2 gives the computer intput/output channel assignments. Subparagraph 3.3.3 and 3.3.4 describe the data interfaces. Subparagraph 3.3.5 details each function supported by the computer program.

3.3.1 Equipment Descriptions

See 3.2.1 and 3.2.2.

3.3.2 Digital Processor Input/Output

See Table 3.3.2-1.

3.3.3 Digital Processor Interface

Refer to Figure 3.2.2-1.

3.3.4 Program Interfaces

Not applicable.

TABLE 3.3.2-1.

COMPUTER INTPUT/OUTPUT CHANNEL UTILIZATION

Channel	Interface Characteristics	Channel Type	Word Size in Bits	Connected Equipment	Number of Input Words	Number of Output Words	Transfer Rate
1	DMA Parallel	Normal	TBD	Mass Storage Device	1 to 8K	1 to 8K	Aperiodic
2	Memodyne Parallel	Normal	16	Refractometer Cartridge Magnetic Tape Unit	1	1	Aperiodic
3	TBD	Normal	TBD	Hard Copy Device	0	1	Aperiodic
4	TBD	Normal	TBD	Display	0	TBD	Aperiodic
5	TBD	Normal	TBD	Keyboard	TBD	0	Aperiodic

3.3.5 Functional Description

The paragraphs below briefly describe the purpose of each function and provide a simplified functional diagram for each.

3.3.5.1 Auto-Mode Function

This function allows the operator to specify a number of IREPS reports to be printed without requiring that an operator entry be made to request each one individually. The printed reports can include outputs of the List, Summary, Cover, and Loss Functions. Figure 3.3.5-1 provides a simplified functional diagram.

3.3.5.2 Cover Function

The Cover Function generates a vertical coverage diagram showing the performance capability of an electromagnetic system. The diagram shows those areas on a height versus range plot where the path loss values are always less than the path loss threshold. A simplified functional diagram for the Cover Function is shown in Figure 3.3.5-2.

3.3.5.3 Edit Function

The Edit Function permits the operator to revise data or amend library contents. Options provide for editing of Environmental Data Sets, Coverage System Data Sets, Loss System Data Sets, and the reports to be generated by the Auto-Mode Function. A simplified functional diagram for the Edit Function is shown in Figure 3.3.5-3.

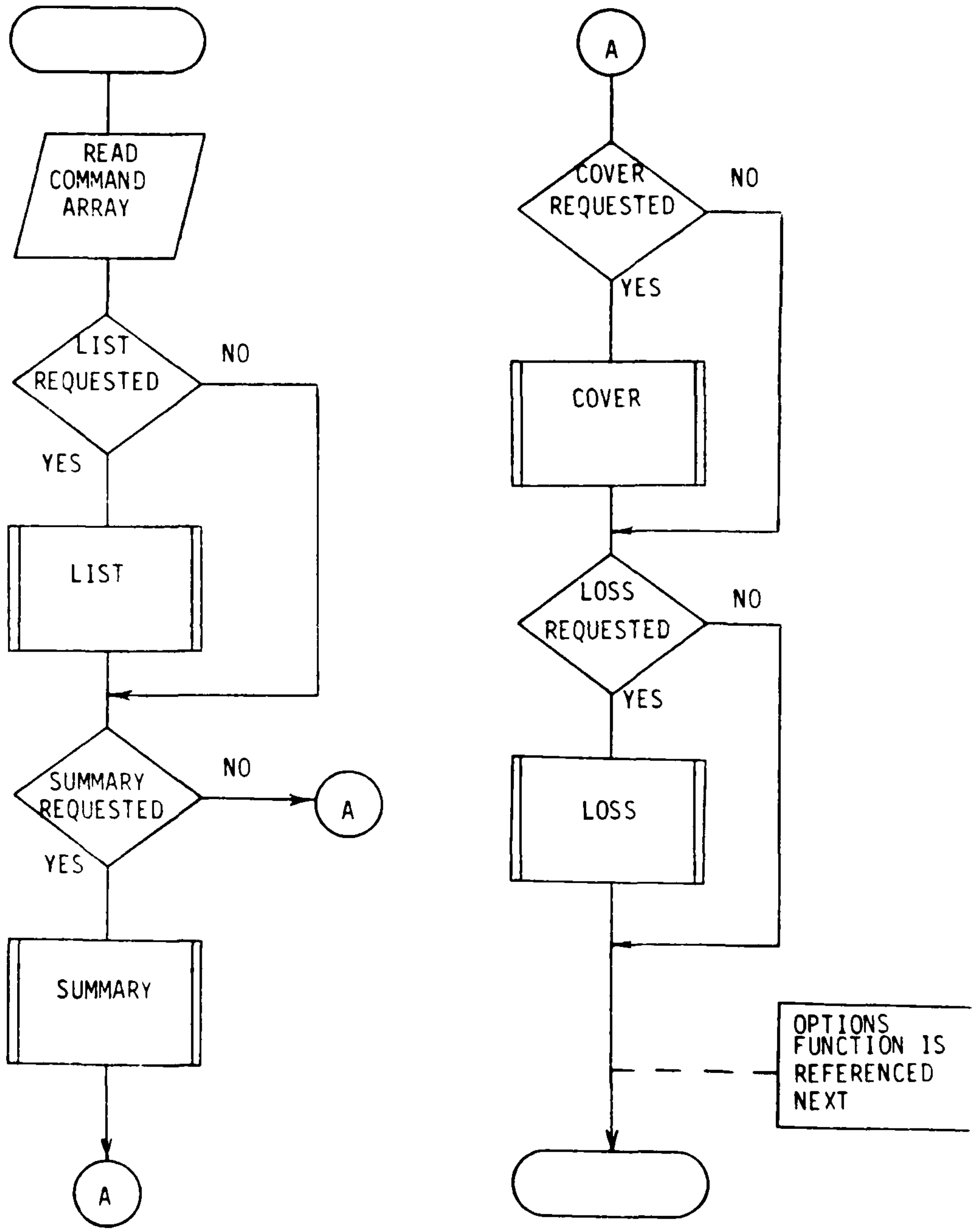


FIGURE 3.3.5-1 SIMPLIFIED FUNCTIONAL DIAGRAM
FOR AUTC-MODE FUNCTION

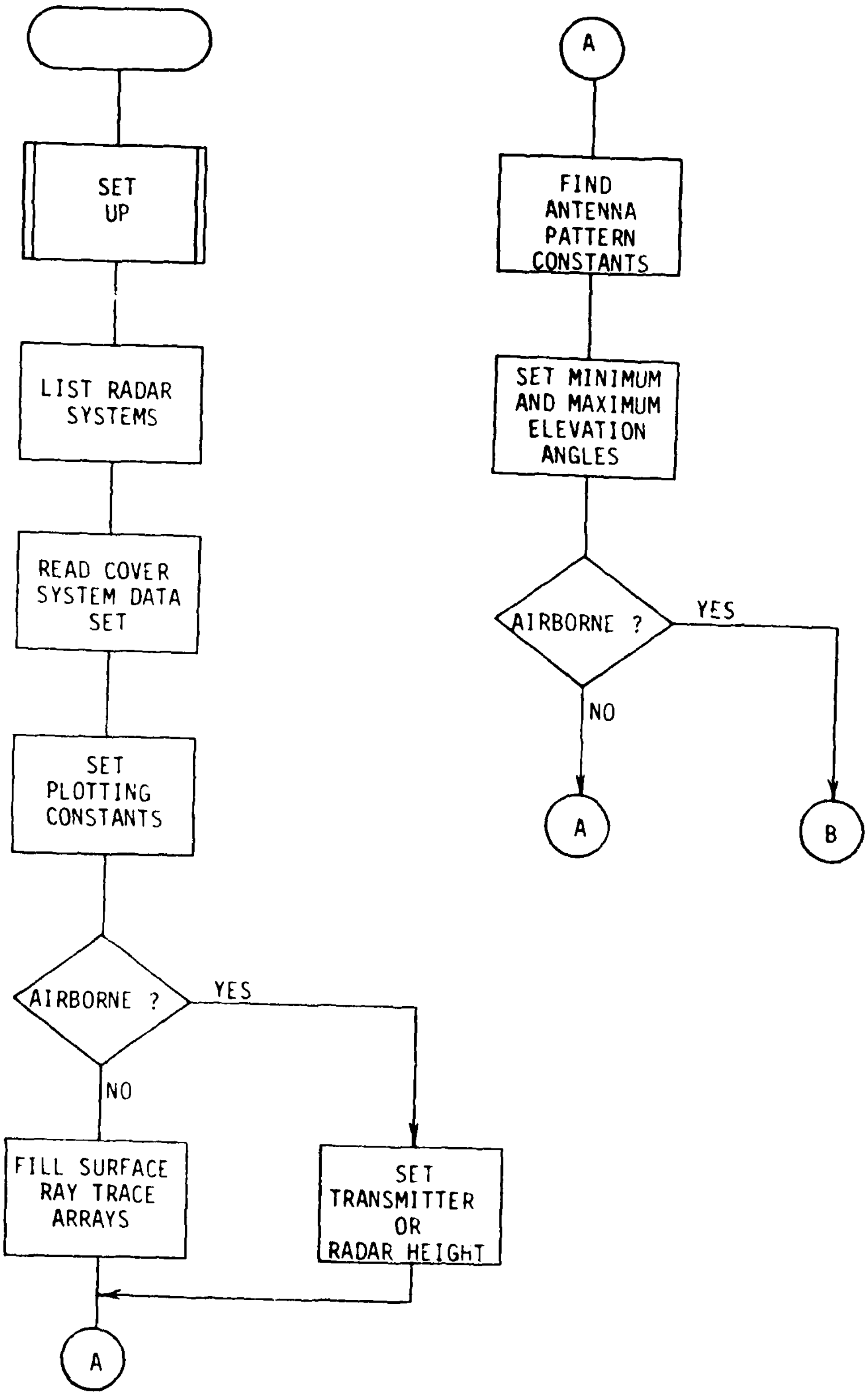


FIGURE 3.3.5-2 SIMPLIFIED FUNCTIONAL DIAGRAM FOR COVER FUNCTION

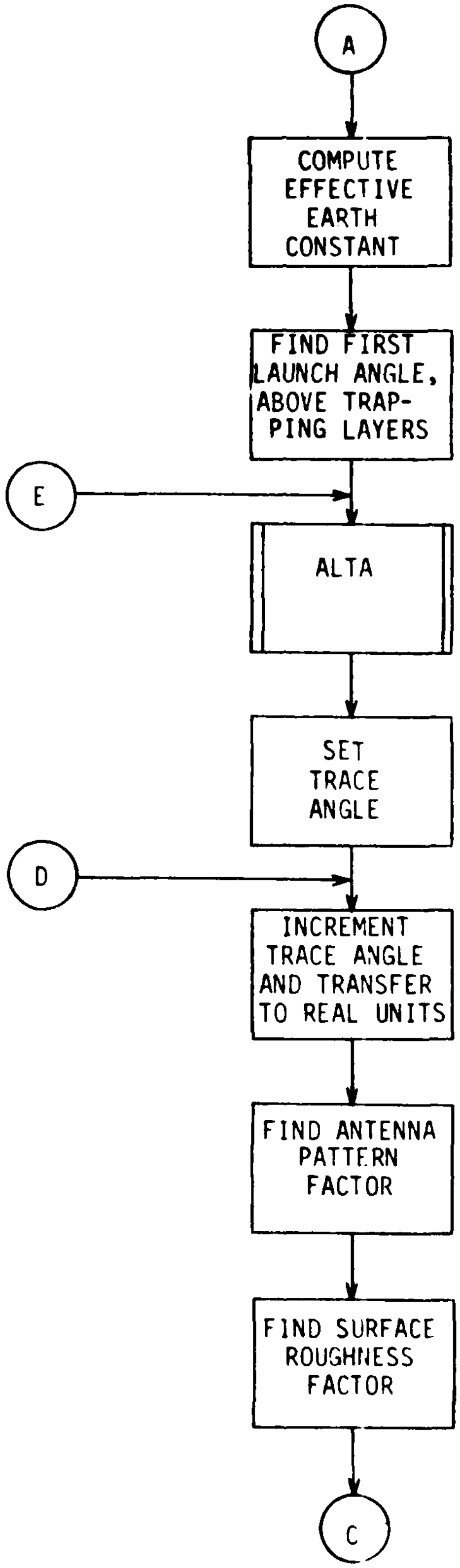


FIGURE 3.3.5-2 SIMPLIFIED FUNCTIONAL DIAGRAM FOR COVER FUNCTION (Cont'd)

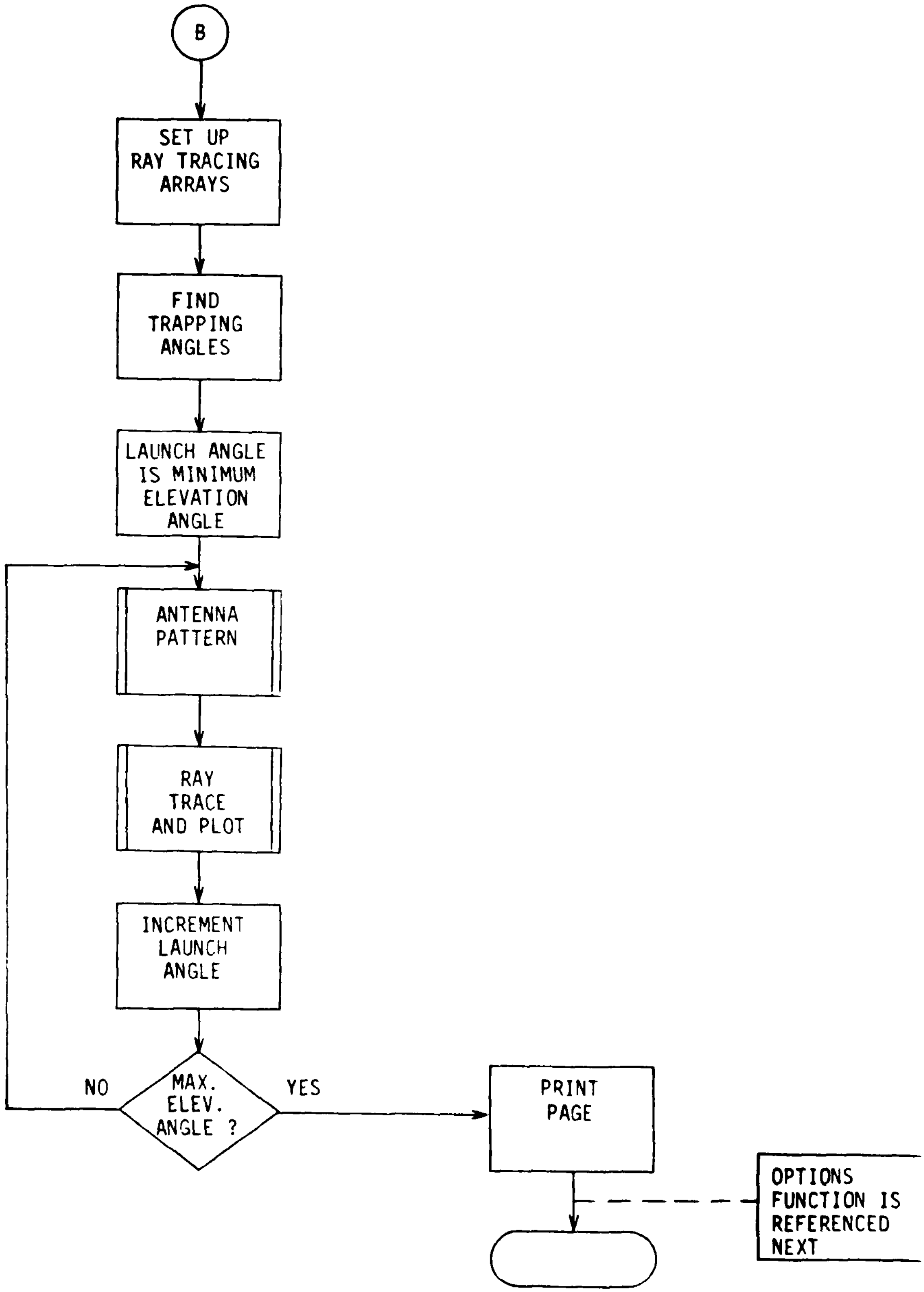


FIGURE 3.3.5-2 SIMPLIFIED FUNCTIONAL DIAGRAM FOR COVER FUNCTION (Cont'd)

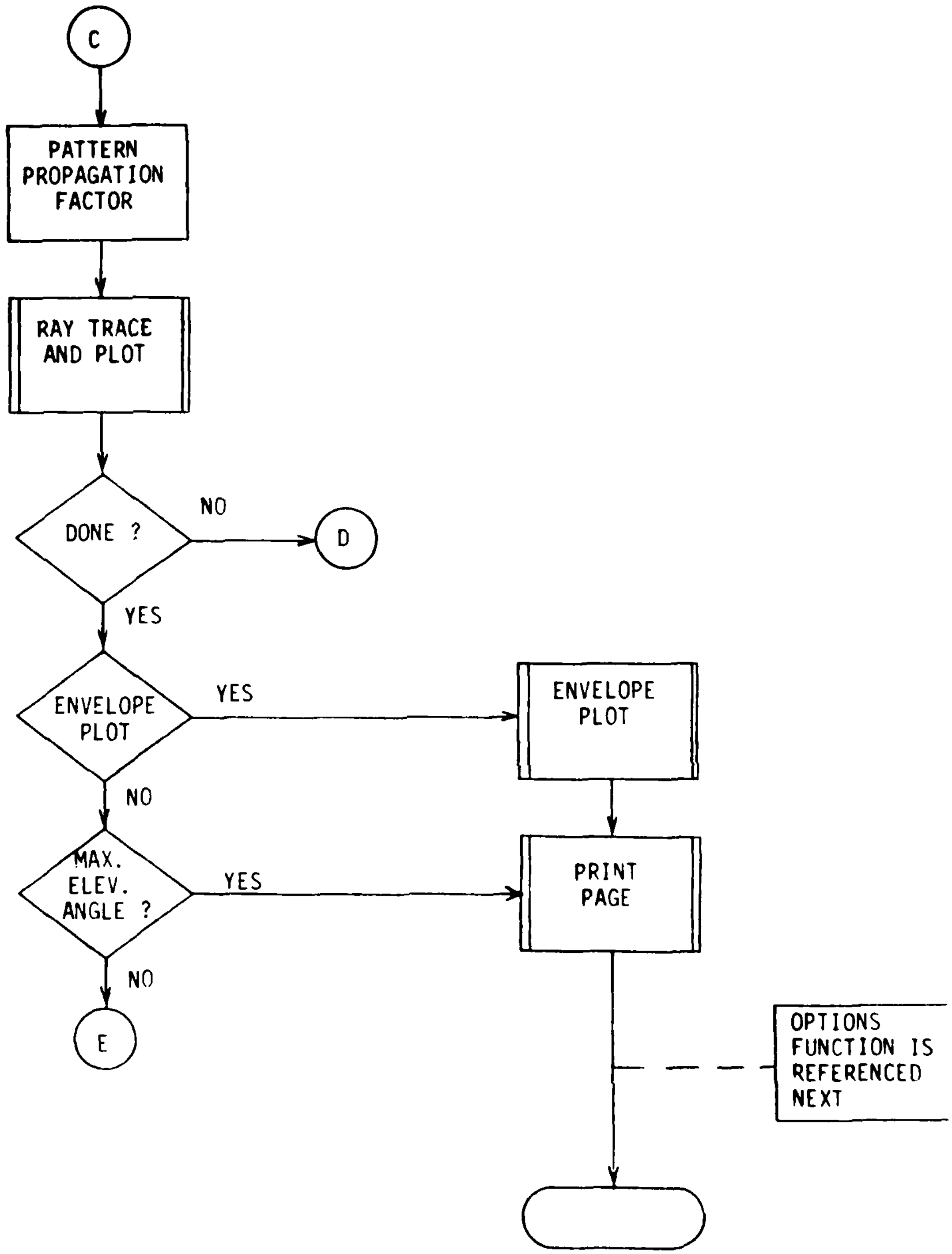


FIGURE 3.3.5-2 SIMPLIFIED FUNCTIONAL DIAGRAM FOR COVER FUNCTION (Cont'd)

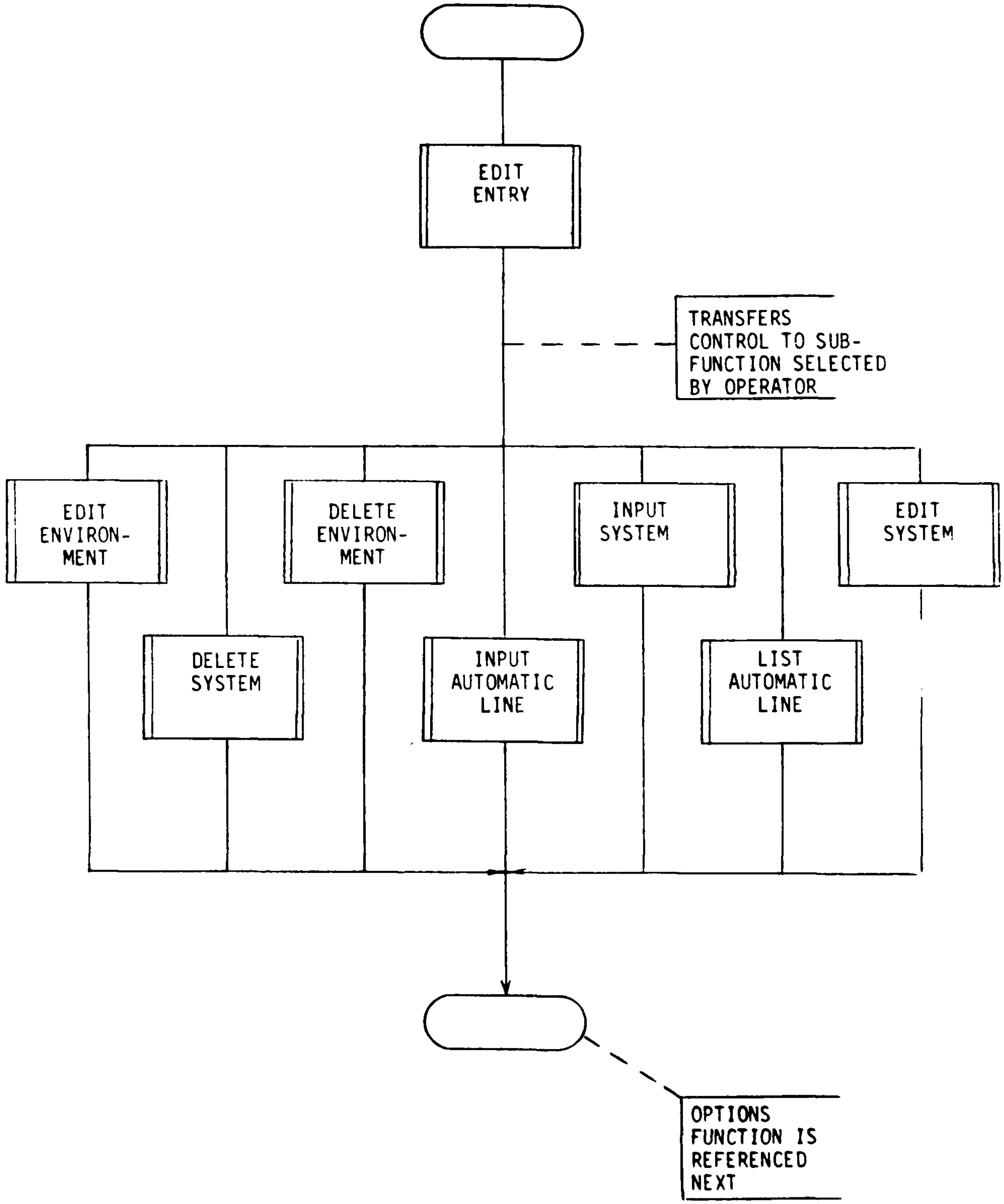


FIGURE 3.3.5-3 SIMPLIFIED FUNCTIONAL DIAGRAM FOR EDIT FUNCTION

3.3.5.4 ESM Function

This function generates tables for U.S. and Soviet emitters listing frequency and maximum intercept range for the selected ESM receiver. A simplified functional diagram for the ESM Range Table Function is shown in Figure 3.3.5-4.

3.3.5.5 Historical Function

This function displays a plot of the world ocean areas to the operator and requests the location to be used in computations. The historical reports for the closest point to the operator entered position are then tabulated on the display. This information becomes the basis for filling the Environmental Data Set arrays. A simplified functional diagram for the Historical Function is shown in Figure 3.3.5-5.

3.3.5.6 Initialize Function

This function starts the IREPS program. A simplified functional diagram for the Initialize Function is shown in Figure 3.3.5-6.

3.3.5.7 Input Function

The purpose of the Input Function is to permit the operator to select one of the existing environmental data sets for processing or to enter a new environmental data set. The operator may enter the new data in any one of several formats:

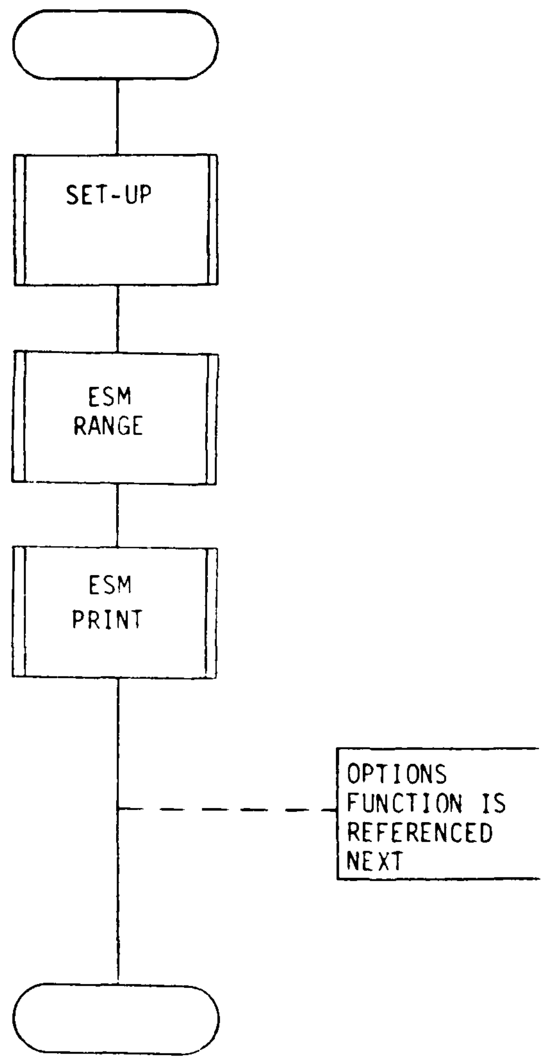


FIGURE 3.3.5-4 SIMPLIFIED FUNCTIONAL DIAGRAM FOR ESM FUNCTION

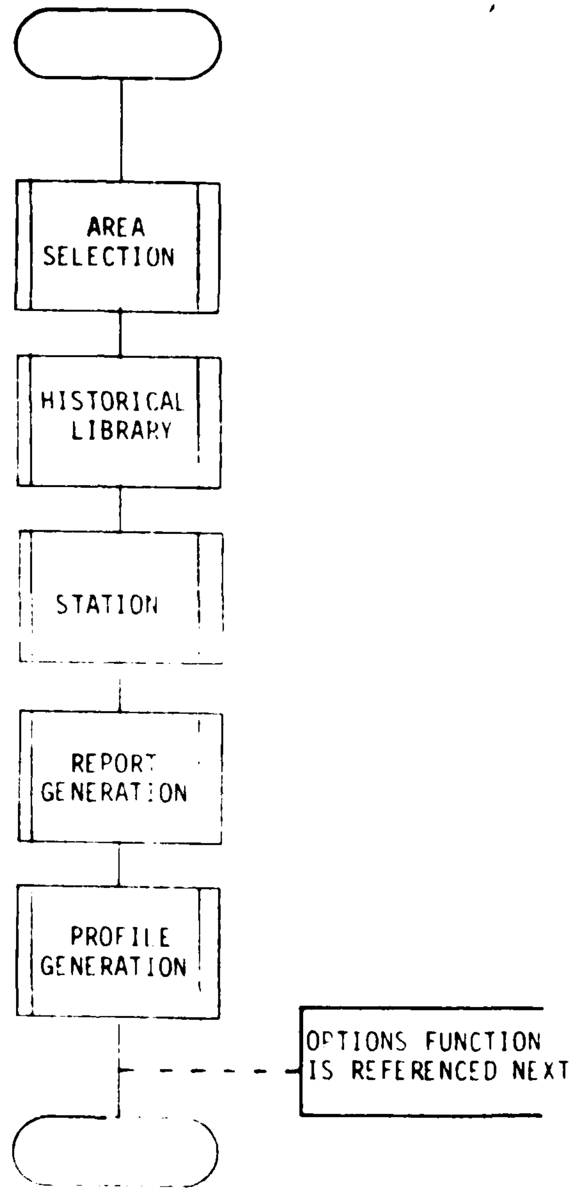


FIGURE 3.3.5-5 SIMPLIFIED FUNCTIONAL DIAGRAM FOR HISTORICAL FUNCTION

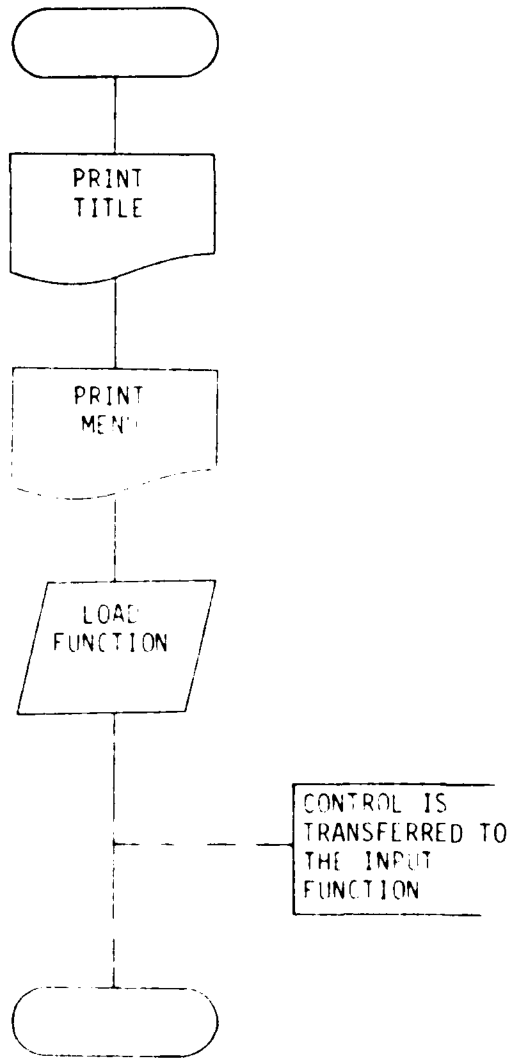


FIGURE 3.3.5-6 SIMPLIFIED FUNCTIONAL DIAGRAM FOR INITIALIZE FUNCTION

a. Radiosonde data

(1) Pressure, temperature, and relative humidity

(2) Ordinate values

b. M units

c. N units

d. WMO message

e. Refractometer

Once entered the data can be stored on the mass storage device for retrieval at a later time. A simplified functional diagram for the Input Function is shown in Figure 3.3.5-7.

3.3.5.8 List Function

This function prints the Environmental Data List, primarily so the operator can verify the numerical entries. A simplified functional diagram for the List Function is shown in Figure 3.3.5-8.

3.3.5.9 Loss Function

The Loss Function provides a path loss versus range plot for a given Environmental Data Set record (see 3.4.7 for a description of the record). The operator inputs identify a Loss System Data Set, a height for the transmitter or radar for airborne systems, and a height for the receiver or target. Loss plots can be provided for either airborne or surface-based EM systems. A simplified functional diagram for the Loss Function is shown in Figure 3.3.5-9.

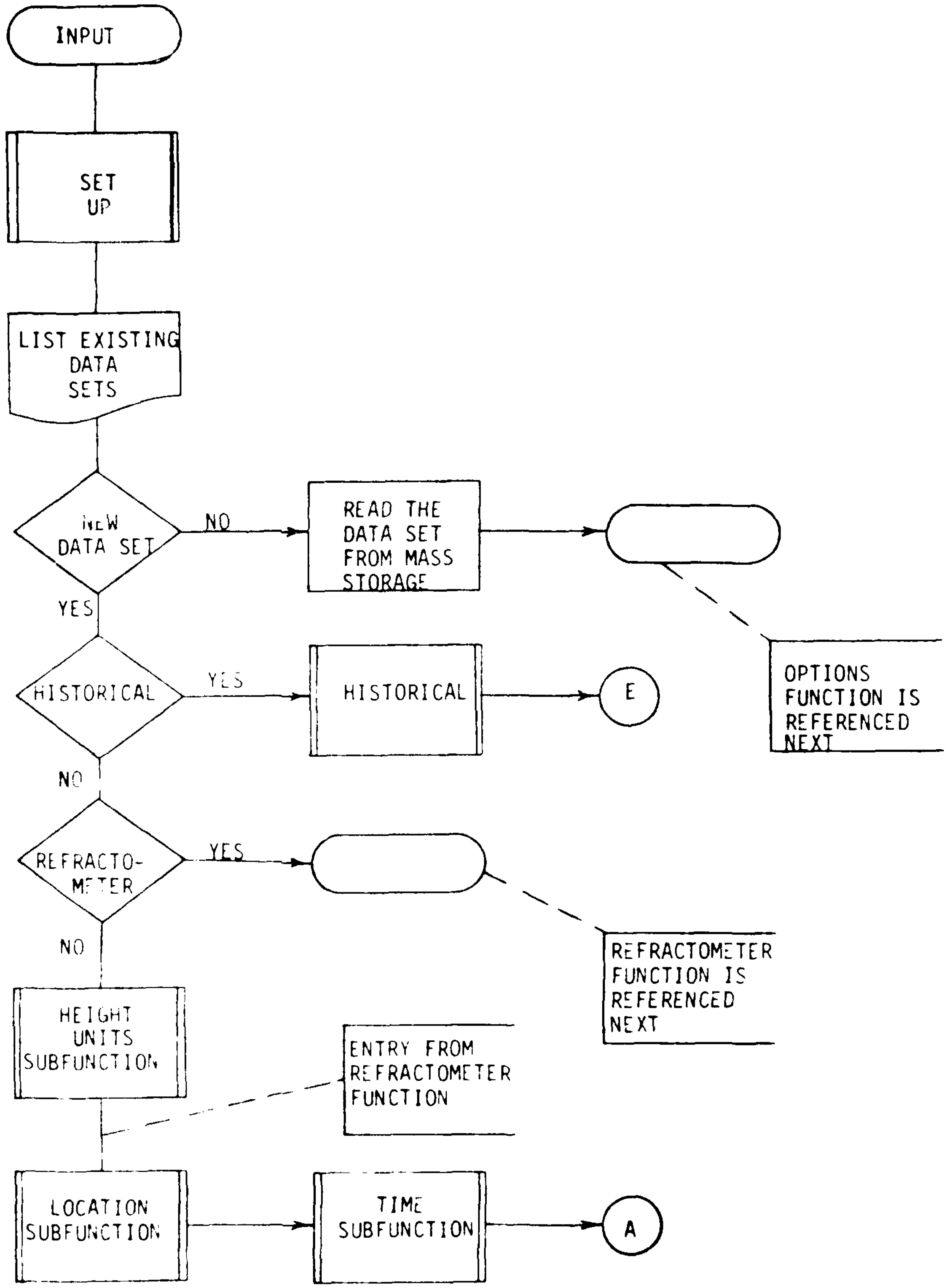


FIGURE 3.3.5-7 SIMPLIFIED FUNCTIONAL DIAGRAM FOR INPUT FUNCTION

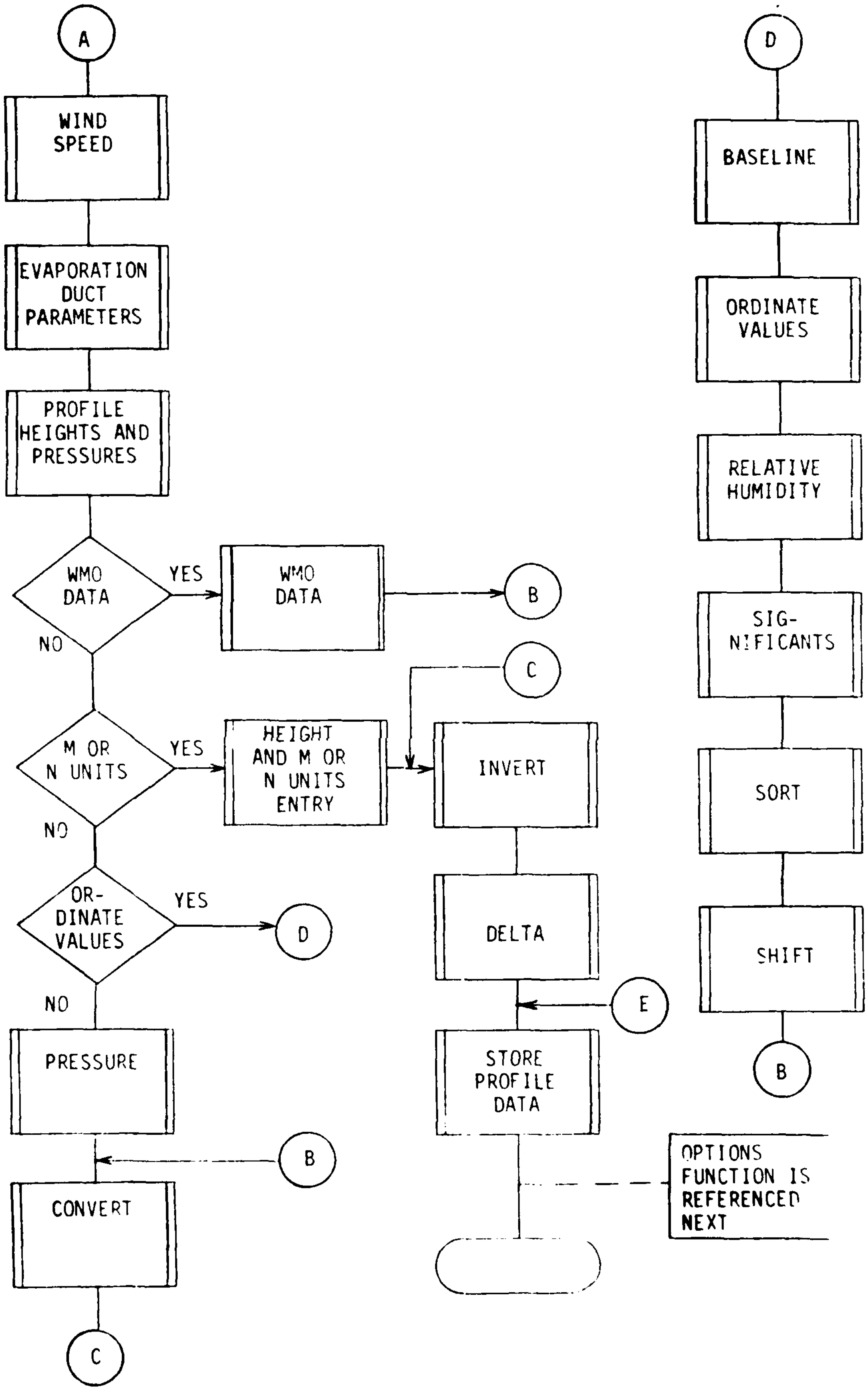


FIGURE 3.3.5-7 SIMPLIFIED FUNCTIONAL DIAGRAM FOR INPUT FUNCTION (Cont'd)

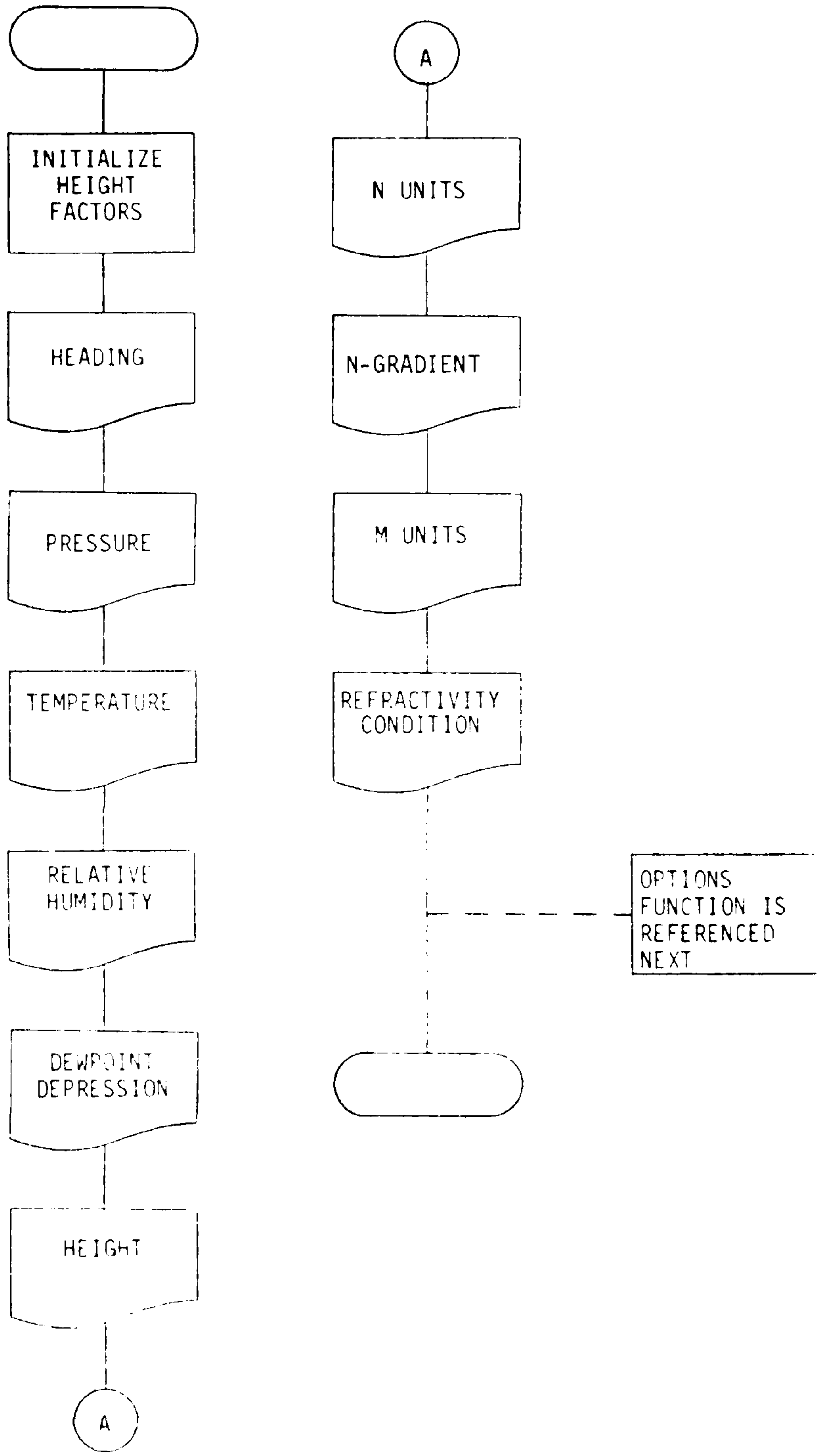


FIGURE 3.3.5-8 SIMPLIFIED FUNCTIONAL DIAGRAM FOR LIST FUNCTION

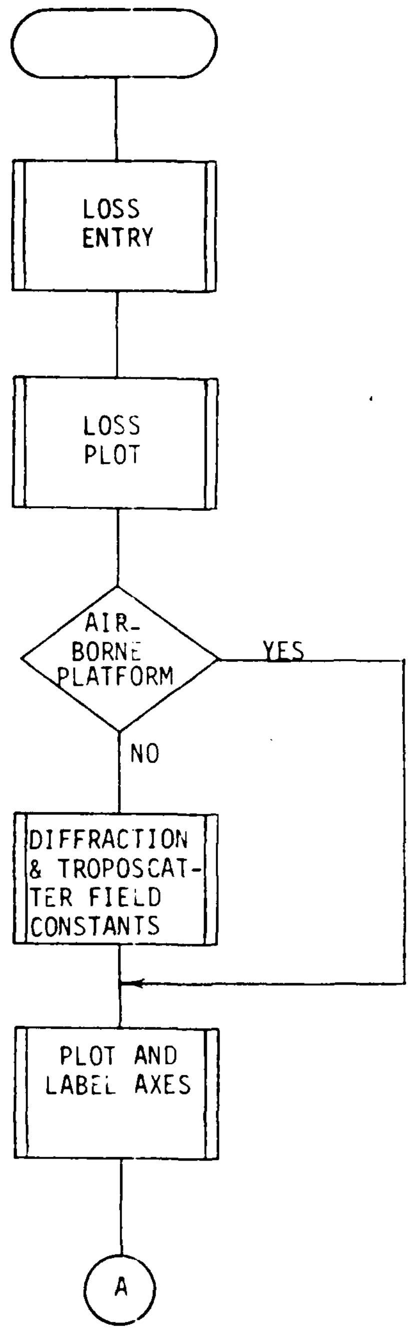


FIGURE 3.3.5-9 SIMPLIFIED FUNCTIONAL DIAGRAM FOR LOSS FUNCTION

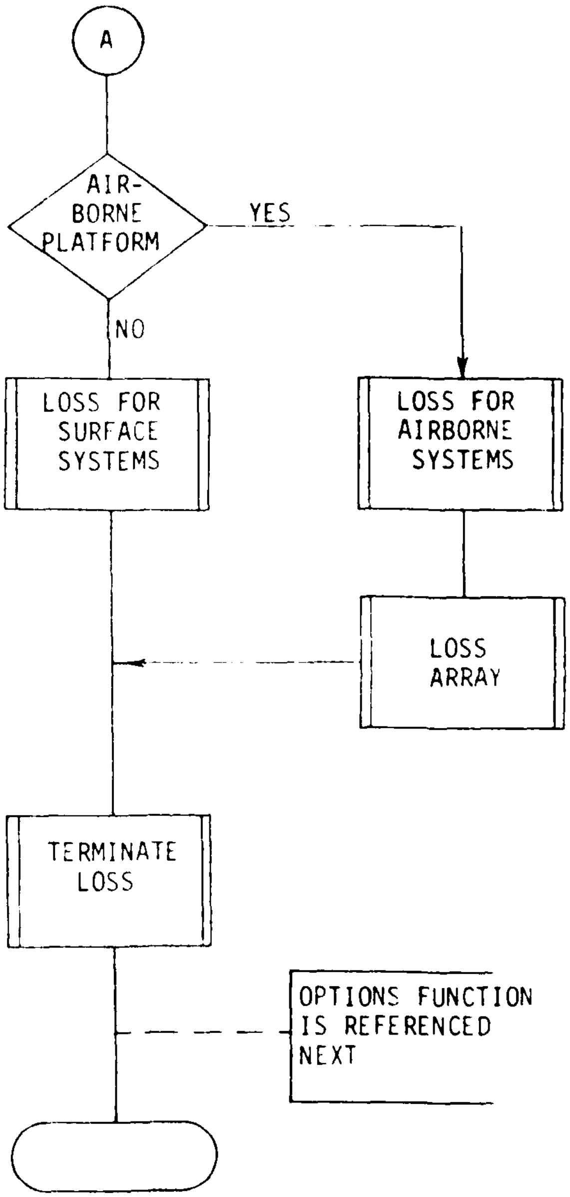


FIGURE 3.3.5-9 SIMPLIFIED FUNCTIONAL DIAGRAM FOR LOSS FUNCTION (Cont'd)

3.3.5.10 Options Function

This function is the central point for operator selection of most major functions of the program. Figure 3.3.5-10 presents a simplified functional diagram. The Options Function is referenced upon exiting from all of the following:

a. Input

b. Summary

c. List

d. Cover

e. Loss

f. Auto-Mode

g. ESM

h. RAOB

i. Surface Search

j. Edit

k. End IREPS

3.3.5.11 RAOB Function

The RAOB Function produces listings of significant and mandatory levels of the sounding, computes meteorological parameters, plots a "Skew T, log p" diagram, and generates an encoded WMO Radiosonde Code message. A simplified functional diagram for the RAOB function is shown in Figure 3.3.5-11.

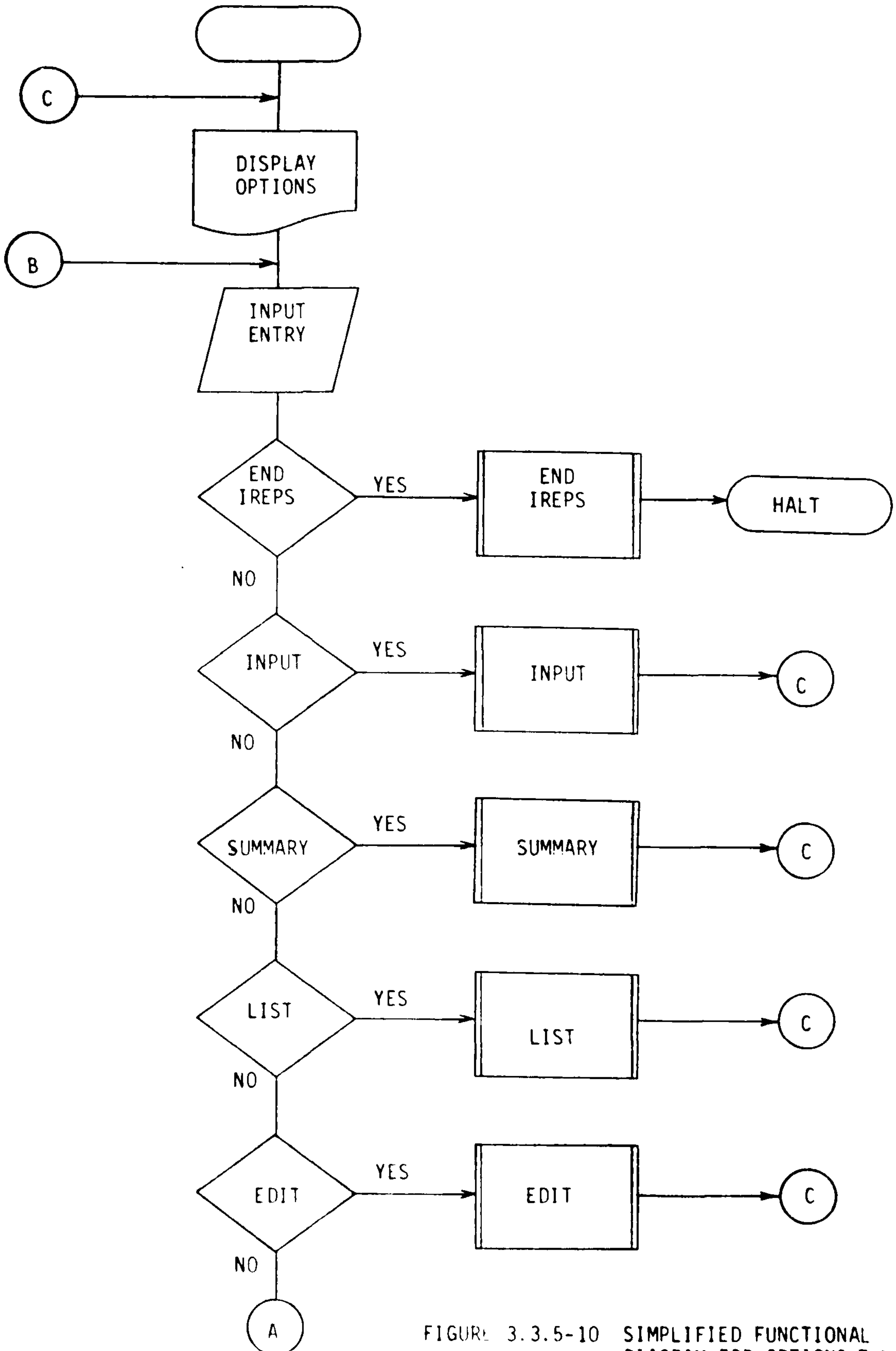


FIGURE 3.3.5-10 SIMPLIFIED FUNCTIONAL DIAGRAM FOR OPTIONS FUNCTION

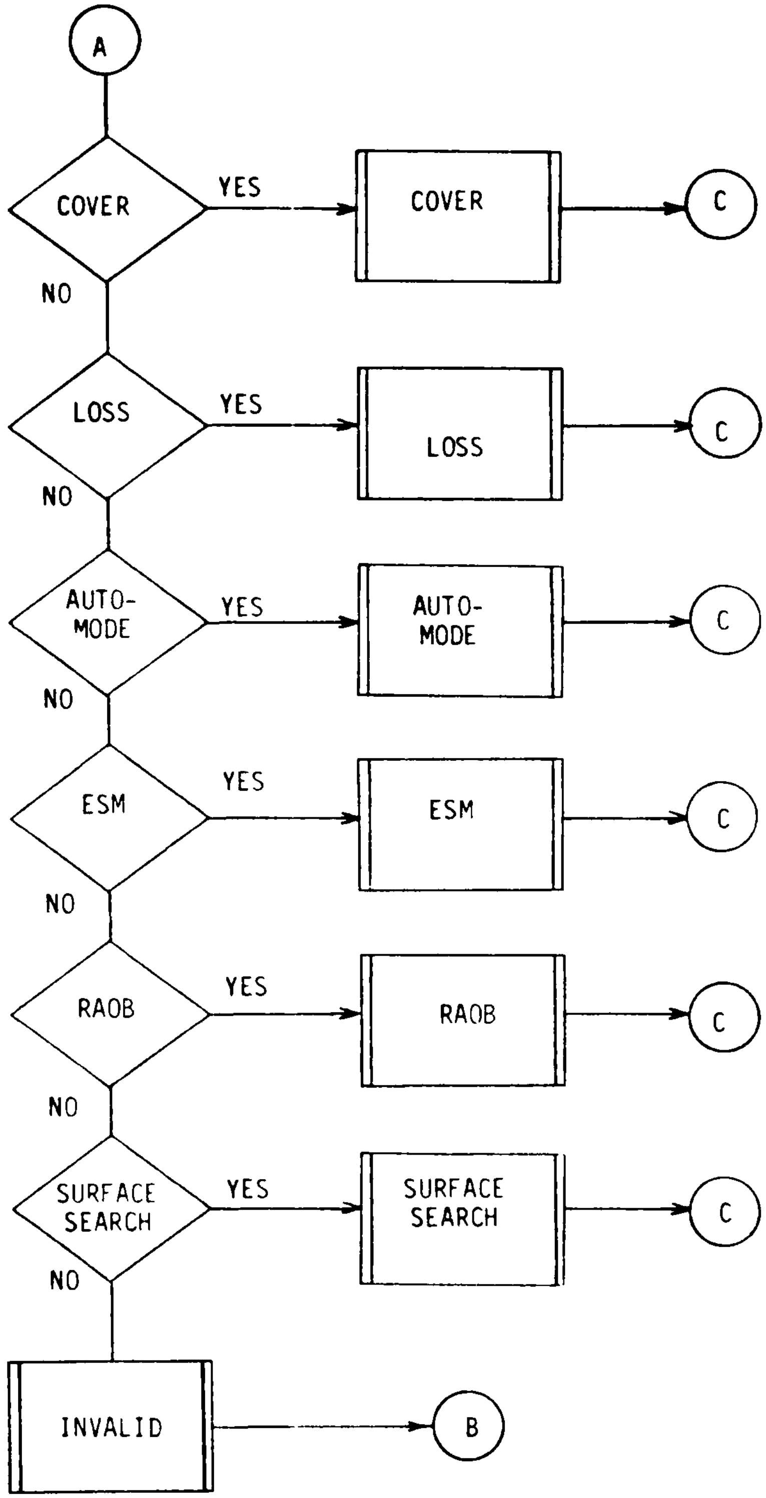


FIGURE 3.3.5-10 SIMPLIFIED FUNCTIONAL DIAGRAM FOR OPTIONS FUNCTION (Cont'd)

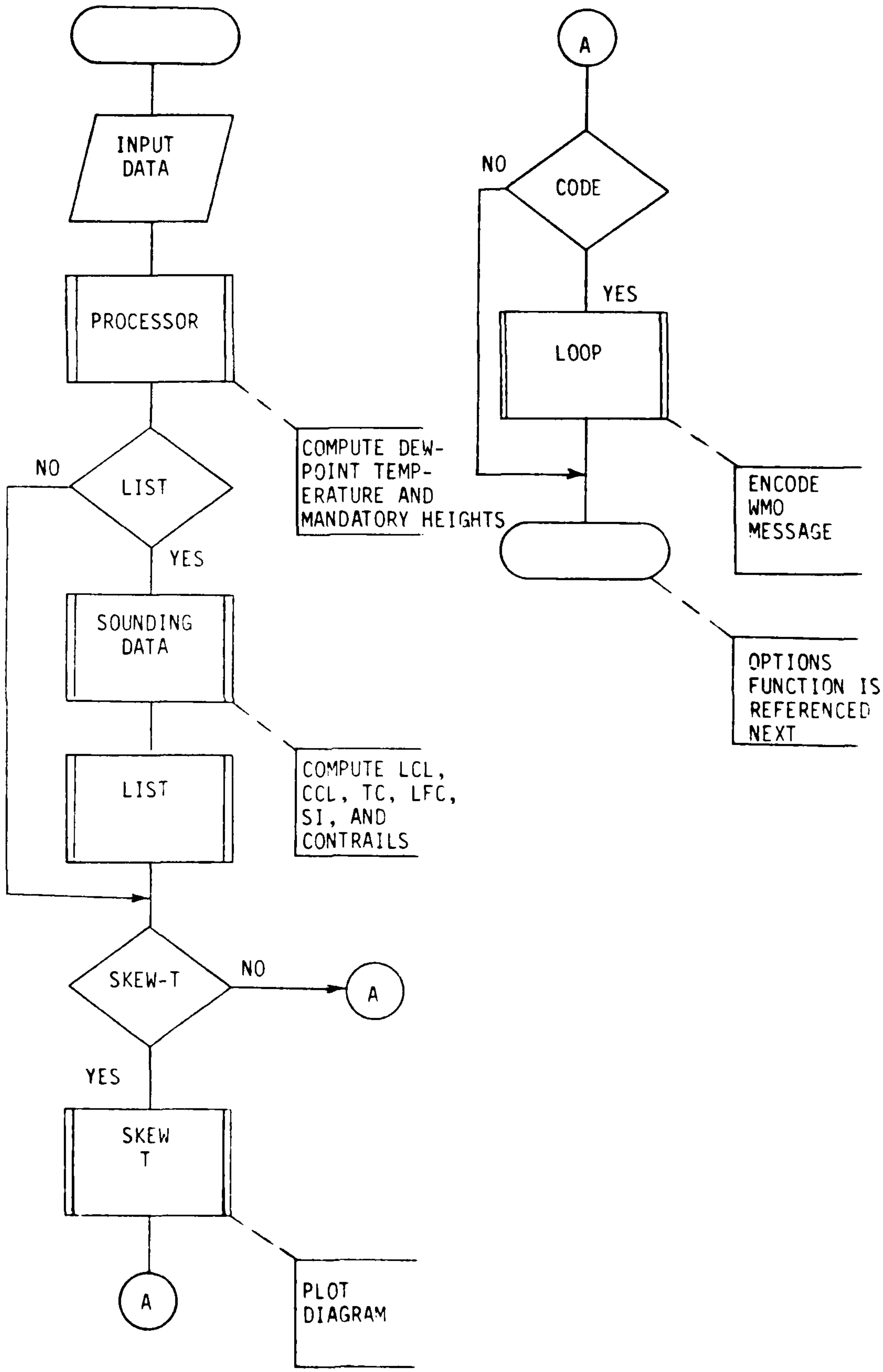


FIGURE 3.3.5-11 SIMPLIFIED FUNCTIONAL DIAGRAM FOR RAOB FUNCTION

3.3.5.12 Refractometer Function

This function reads the refractometer data tape and generates a finite straight-line segment approximation for the altitude/refractivity contour. The data is reformatted for use by other IREPS functions. A simplified functional diagram for the Refractometer Function is shown in Figure 3.3.5-12.

3.3.5.13 Summary Function

This function generates a propagation conditions summary report. The report shows the refractive conditions from the Environmental Data Set. A narrative description on an EM system-independent basis is also provided. A simplified functional diagram for the Summary Function is shown in Figure 3.3.5-13.

3.3.5.14 Surface Search Function

This function generates a table of minimum, maximum, and average detection ranges for U.S. and Soviet ships based on the type of radar and antenna height. A simplified functional diagram for the Surface Search Function is shown in Figure 3.3.5-14.

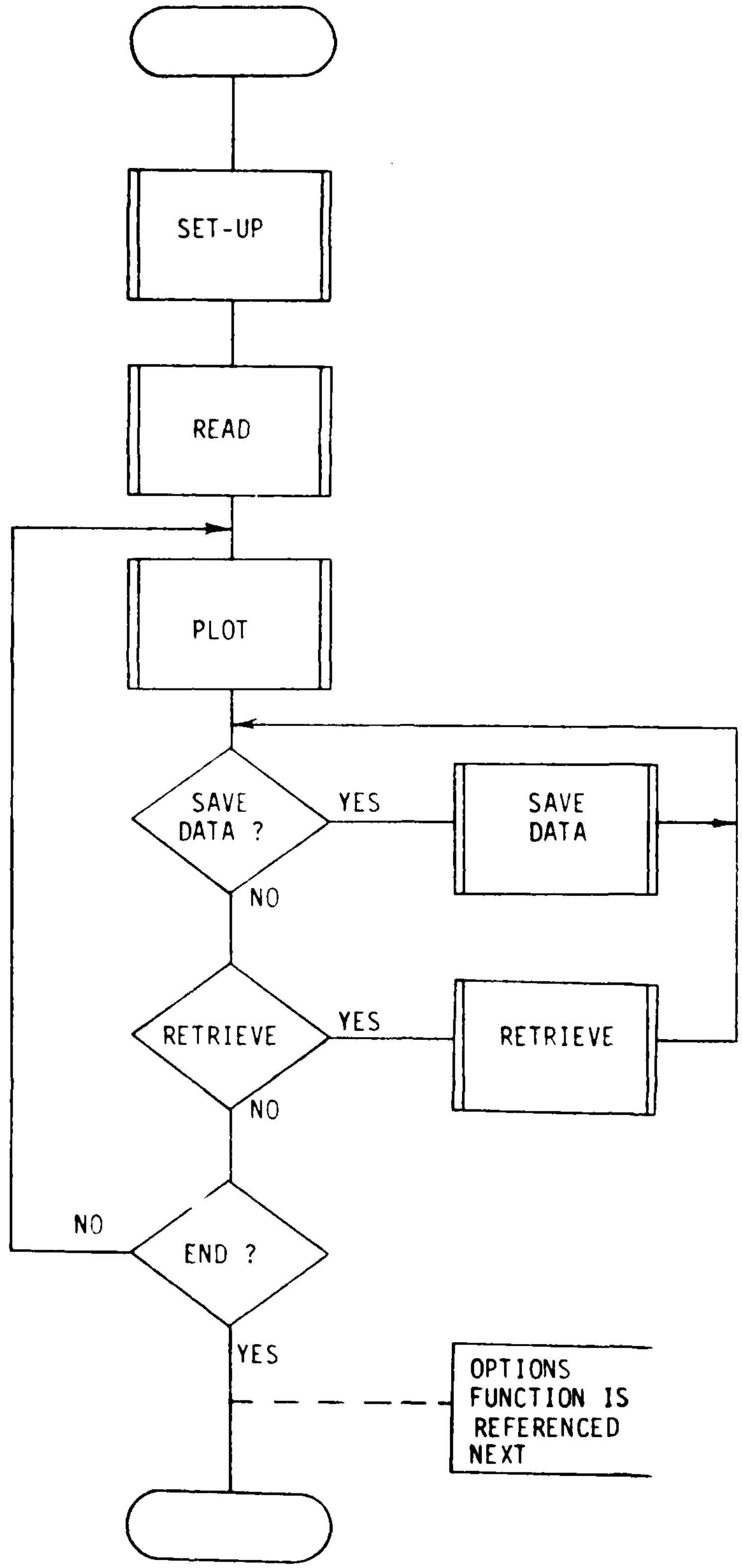


FIGURE 3.3.5-12 SIMPLIFIED FUNCTIONAL DIAGRAM FOR REFRACTOMETER FUNCTION

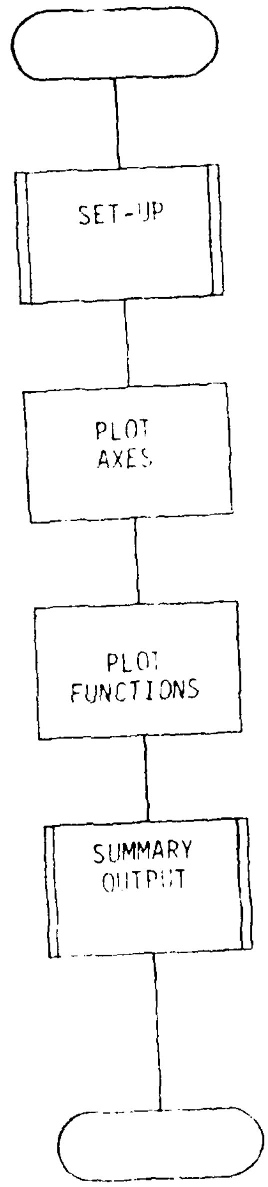


FIGURE 3.3.5-13 SIMPLIFIED FUNCTIONAL DIAGRAM FOR SUMMARY FUNCTION

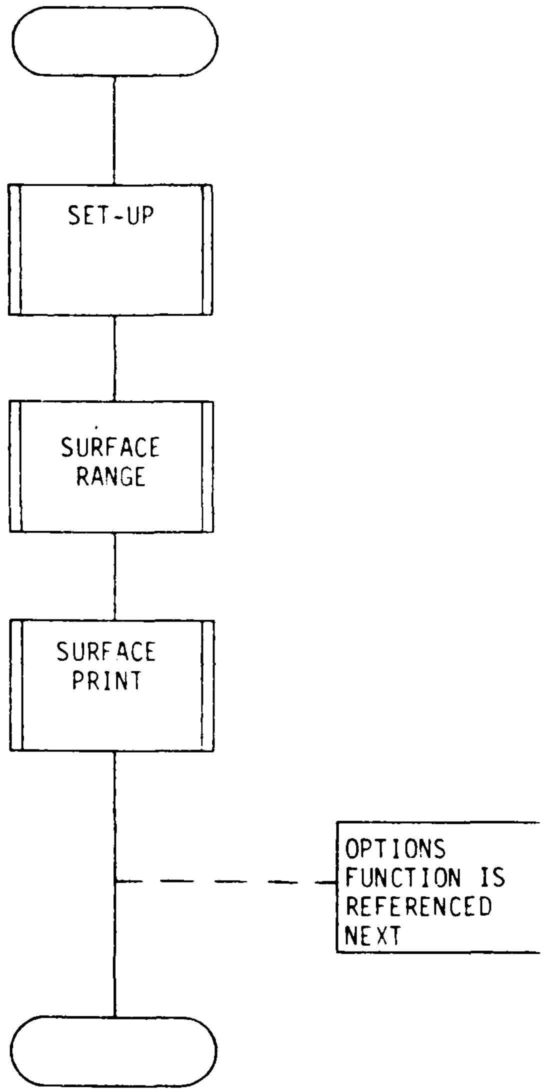


FIGURE 3.3.5-14 SIMPLIFIED FUNCTIONAL DIAGRAM FOR SURFACE SEARCH FUNCTION

3.4 Detailed Functional Requirements

The following paragraphs describe the logical and mathematical processing for each of the functions of the IREPS program.

A Note of Terminology

In this section, the terms: "reference", "invoke", "call", or "execute" are used interchangeably to mean the initiation of a subroutine, procedure, function, or other predefined process. Upon completion of the processing, control returns to the routine that called the predefined process. The term "transfer of control" means that a jump is implied, and the routine that transferred control does not get it back upon completion of the subsequent processing.

3.4.1 Auto-Mode Function

This function allows the operator to generate a series of IREPS reports without manually requesting each one.

3.4.1.1 Automatic Subfunction

3.4.1.1.1 Inputs

None

3.4.1.1.2 Processing

This subfunction is called from the Options Function. This subfunction reads the Command File Array from the mass storage device. The array structure is shown in Figure 3.4.1-1. The first row contains

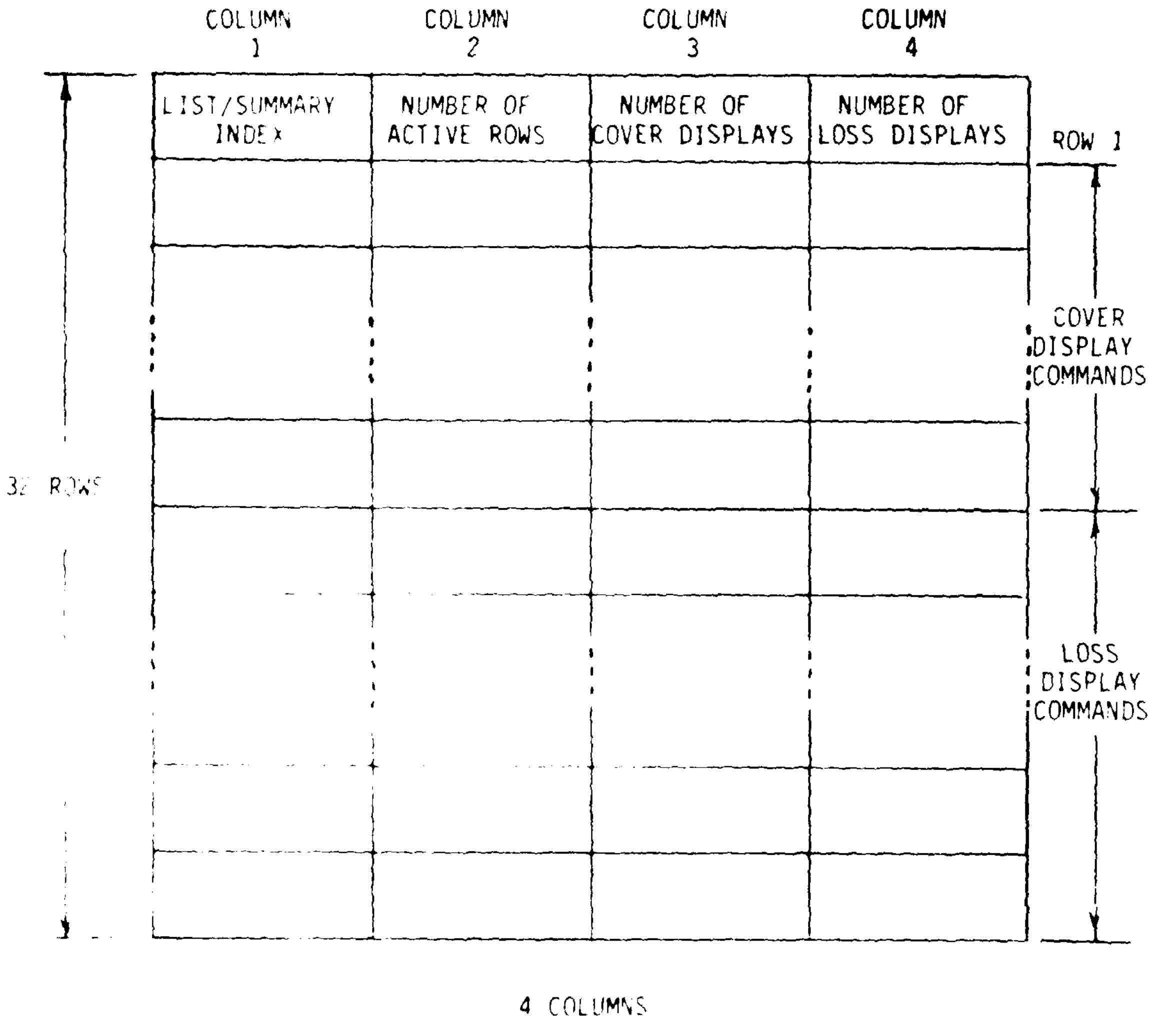


FIGURE 3.4.1-1 COMMAND FILE ARRAY

a description of the entries in the array.

In row 1, column 1 the list/summary index identifies the number of "list products" in the most significant digit (0 to 9) and the number of "summary products" in the least significant digit (0 to 9). If this index is non-zero, the List and/or Summary Function(s) are referenced. After the summary and data lists are printed, the Cover and Loss Functions are referenced in turn (if there are appropriate commands in columns 3 and 4 of the array). Finally a message is displayed to the operator when all commands have been executed and control is returned to the Options Function (3.4.10).

3.4.1.1.3 Outputs

IREPS products and a message display to the operator upon completion.

3.4.2 Cover Function

The purpose of the Cover Function is to display a vertical coverage diagram showing the performance capability of an electromagnetic system. The diagram shows those areas on a height-vs-range plot where path loss values are always less than the path loss threshold. All internal calculations are performed in mks units, unless otherwise stated Figure 3.4.2-1 is an example of such a display.

The sample figure gives the coverage diagram for an AN/SPS-43 radar operating at 215 MHz in a standard atmosphere. The antenna is 131 ft. above sea level, and the coverage plot is based on a free space detection range of 100nm. The shaded portions of the diagram represent areas in which the path loss is less than the threshold for detection, therefore. an area where the radar would be expected to detect air targets. The display shows the effects of the interference region with the lobes that extend out to 200 nm and the deep interference nulls that reduce the detection range to within 40 nm.

The cover plot for surface-based systems can account for up to three regions as listed below:

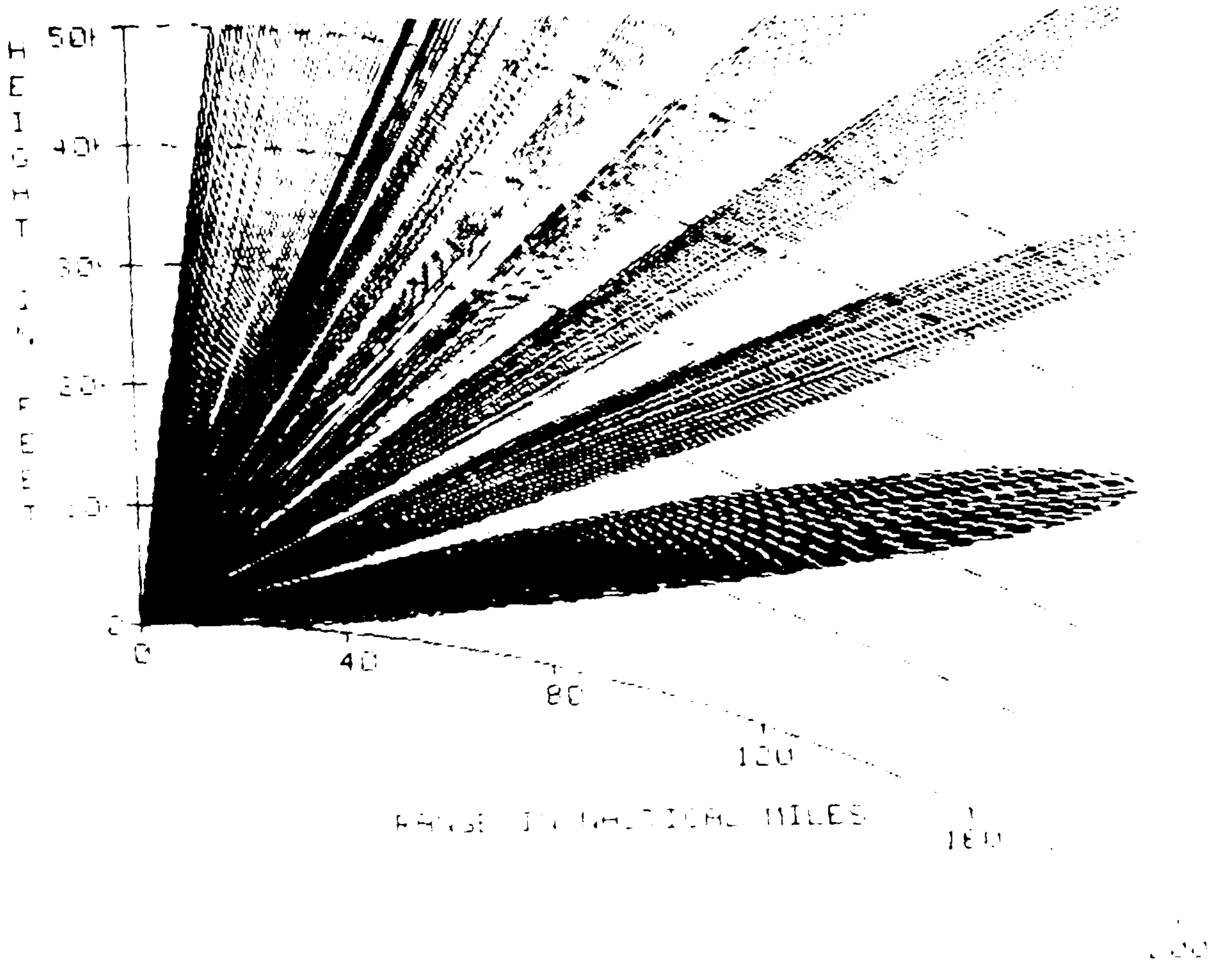
a. The optical interference region is dominated by coherent interference between direct and sea-reflected waves. This region is always within the radio horizon.

b. The diffraction field region applies to ranges somewhat greater than the radio horizon. The loss in this region is due to diffraction around the earth's surface. This loss can usually be represented as a single waveguide mode solution to the series equation

**** COVERAGE DISPLAY ****

SPS-43A

LOCATION: NOT SPECIFIED
DATE/TIME: EL DUCT 15 TO 17 KFT



AIR-SEARCH RADAR
BASED ON FREE SPACE DETECTION RANGE OF 100 NM FOR ARBITRARY AIR TARGET

SHADED AREA INDICATES AREA OF DETECTION OF COMMUNICATION

FREE SPACE RANGE: 100.0 NAUTICAL MILES
FREQUENCY: 21[illegible] MHZ
TRANSMITTER OR RADAR ANTENNA HEIGHT: 111.0 FEET

Figure 3.4.2-1. Typical Coverage Display which describes the electric field in this region.

c. The intermediate region accounts for the transition between the optical interference and diffraction field regions. In the intermediate region, the actual solution for the electric field strength is very complicated, so a linear interpolation method of solution is used.

The cover plots for airborne systems provide line-of-sight ranges only (tangent ray limited). No two-path interference, diffraction, or troposcatter calculations are made for these plots. The plots are analogous to the loss diagrams for airborne systems described in 3.4.9.

The discussion which follows assumes that the reader is familiar with the material presented in NOSC TN 669 and NELC TN 3037. Furthermore, the reader should carefully distinguish between the two height variables used in these calculations:

Ht - The transmitter or radar antenna height

Hr - The target or receiving antenna height

3.4.2.1 Cover Entry Subfunction

3.4.2.1.1 Inputs

a. ASCII array containing the names of up to 32 EM systems.

b. Record number of the desired EM system

c. Transmitter or radar antenna height (Ht)

d. A 32 element array indexing the active elements in the names of radar systems array (a. above)

e. Display flag. Indicates the height, range, and units of the plot

3.4.2.1.2. Processing

This subfunction is called from the Options Function. This subfunction first references the Set-Up Subfunction (3.4.2.2) to initialize variables, arrays, and files. If the operator enters the "Options" command, the Options Function (3.4.10) is invoked.

The menu of radar systems stored in the name array is presented to the operator If there are no radar systems in the array, then a warning message is displayed and control is transferred to the Options Function. Otherwise, a message is displayed prompting the operator to choose a radar system. If the operator enters the "Back-Up" command, then the Options Function is invoked. If the operator chooses an invalid radar system, the Error Subfunction (3.4.2.2.4) is referenced and the operator is again prompted to select a radar system. If the operator requests a valid radar system, its Cover System Data Set is read from the mass storage device. If the display flag is set to G (see 3.4.3.15.2), the operator is presented with a menu of the display types and prompted to choose one. The display flag is set to the appropriate code. (The default is the first item.) Table 3.4.2-1 lists the choices provided. If the operator enters the "Back-Up" Command, the Options Function is invoked. If an invalid display type is chosen, the Error Subfunction is called and the operator is again requested to choose a display type. If the radar is on a surface platform, the Cover Plot

Subfunction (3.4.2.3) is invoked. Otherwise, the operator is requested to input Ht in metres or feet (depending on the setting of the display flag). If Ht is entered in feet, it is converted to metres by multiplying by 0.3048. The Cover Plot Subfunction is then called.

Table 3.4.2-1. Types of Displays

Description		Code
Altitude	Range	
50,000 ft	200 nm	A
25,000 ft	100 nm	B
10,000 ft	50 nm	C
20,000 m	400 km	D
10,000 m	200 km	E
5,000 m	100 km	F

3.4.2.1.3 Outputs

a. Menu of EM systems

b. Operator prompts

c. Menu of display types (with altitude and range limits)

d. Display flag

e. Prompt for antenna height

f. Cover System Data Set with the following variables

(1) Name of the EM system - 24 ASCII character string

(2) Display flag which indicates the units, height, and range for the plot

(3) Flag indicating if the platform is airborne or surface-based

(4) Antenna height (metres)

(5) Frequency (MHz)

(6) Free space range (km)

(7) Antenna type flag indicating the directional pattern for the antenna

(8) Antenna vertical beamwidth (degrees)

(9) Elevation angle of the antenna (degrees)

(10) Security classification of the radar system

(11) Label-two lines (160 ASCII character)

3.4.2.2 Setup Subfunction

3.4.2.2.1 Inputs

None

3.4.2.2.2 Processing

This subfunction is called by the Cover Entry Subfunction. Initializes data for the Cover Function. The principal data items include the Environmental Data Set and the Automatic Data Set. File initialization is also performed. Control is returned to the calling subfunction.

3.4.2.2.3 Outputs

None.

3.4.2.3 Cover Plot Subfunction

3.4.2.3.1 Inputs

a. Display flag. Indicates units, height, and range for the plot.

b. Platform flag. Indicates airborne or surface-based.

3.4.2.3.2 Processing

This subfunction is called by the Cover Entry Subfunction. All internal calculations use metric units. If the display flag indicates that the range of the plot is in nautical miles and the height is in feet, the range factor is set to 1/1.853184 and the height factor is set to 1/0.3048. Otherwise, the height and range factors are 1.

The maximum height, Hmax, and range, Rmax, of the plot are set to the value indicated by the display flag and have units of metres and kilometres, respectively.

The type of plot used is a 4/3 earth plot. It closely approximates a segment of a polar plot. Zero height is established where the radius vector is 6371 km. In this region, the range increases linearly across the plot and the height at any range, R, differs from a linear plot by an offset of

$$\frac{-3}{(8)(6.371)} R^2$$

In order for the plot to include zero metres altitude at range Rmax, the height offset is set to

$$Hoff = \frac{3}{(8)(6.371)} Rmax^2$$

The altitude axis is plotted and labeled at five intervals in terms of the operator selected units. The range axis is plotted at those heights and is labeled in terms of the proper units. The elevation transformation constants are then calculated using

$$F = 0.099 \frac{\text{Maximum Display Height}}{\text{Maximum Display Range}}$$

$$T_3 = \tan^{-1} (1.9648F)$$

$$T_4 = \tan^{-1} (14.101F)$$

Constants are then computed for use in Subfunctions FNS (3.4.2.4) and FNT (3.4.2.5).

$$X_2 = \frac{(T_4 - T_3)}{\frac{T_4}{1.5} - \frac{T_3}{1.4}}$$

$$X_3 = \frac{T_3}{1.1} X_2 - T_3$$

$$X_1 = X_2 X_3$$

If the platform flag indicates that the system is airborne, the Airborne Subfunction (3.4.2.6) is called. Otherwise, the Surface Subfunction (3.4.2.7) is called.

3.4.2.3.3 Outputs

a. Height Factor

b. Range Factor

c. The maximum range of the plot in km (Rmax)

d. The maximum height of the plot in metres (Hmax)

e. Height offset in metres at zero range (Hoff)

f. Constants for the elevation angle transformations

g. Plot axis plotted and labeled

3.4.2.4 FNT Subfunction

3.4.2.4.1 Inputs

a. The display elevation angle (radians)

b. Constants for the elevation angle transformations

3.4.2.4.2 Processing

This subfunction is called by the Airborne, Surface, and Cover Plot Subfunctions. This subfunction is used to convert the apparent elevation angle on the coverage plot to the true elevation angle at the antenna. (The difference in angle is due to the extreme height-to-range ratio of the display scales which vary from 1:20 to 1:30.) The true elevation angle of the ray is calculated using the following formula

$$AT = SIGN(AD) \left(\frac{X1}{X2 - |AD|} - X3 \right)$$

where

AD = display elevation angle

X_1, X_2, X_3 = constants computed in the Cover Plot Subfunction

SIGN = sign function

Control is returned to the calling subfunction

3.4.2.4.3 Outputs

The true elevation angle of the ray (radians)

3.4.2.5 FNS Subfunction

3.4.2.5.1 Inputs

a. The true elevation angle of the ray (radians)

b. Constants used for the elevation angle transformations

3.4.2.5.2 Processing

This subfunction is called by the Airborne, Surface, and Cover Plot Subfunctions. This subfunction converts the true elevation angle at the antenna to the apparent elevation angle on the coverage plot. (The difference in angle is due to the extreme height-to-range ratio of the display scales which vary from 1:20 to 1:30.) The display elevation angle is calculated using the following formula

$$AD = SIGN(AT)\left(X2 - \frac{X1}{|AT| + X3}\right)$$

where

AT = true elevation angle of the ray.

X_1, X_2, X_3 = constants computed in the Cover Plot Subfunction.

SIGN = Sign function

Control is returned to the calling subfunction.

3.4.2.5.3 Outputs

The display elevation angle (radians)

3.4.2.6 Airborne Subfunction

3.4.2.6.1 Inputs

a. Environmental data set (see 3.4.7)

b. Cover System data set (see 3.4.3)

3.4.2.6.2 Processing

This subfunction is called by the Cover Plot and Surface Subfunctions. This subfunction first sets up arrays and constants which are needed for the following calculation using the M units array. The minimum refractivity of the profile (Mm) is found, as well as the minimum refractivity at or above the antenna (Ma), and the height at which Ma occurs (Htop). The ray tracing arrays are filled in order of increasing height with an entry for each layer boundary and an additional entry for Ht. A pointer is set, to index the entry at Ht.

The arrays used for ray tracing are then filled starting at that height. Array Hmrs contains the height at which each layer starts (in order of increasing height) starting with Ht. Array Twodm contains 2 x 10^{-6} times the change in refractivity of each layer. Array Dmdh contains 10^{-3} times the change in modified refractivity with height starting at Ht. Each item in the Dmdh array is found by the following equation.

$$\mathrm{Dmdh}(i) = 10^{-3} \frac{\Delta M(i)}{\Delta H(i)}$$

where i = current layer

ΔM = change in modified refractivity through the layer

ΔH = change in height through the layer

The refractivity at the antenna height is also found.

The minimum angle, below which all rays are not trapped but are reflected is

$$\alpha_r = - [\, 2 \,(\mathrm{Antmun} - M_m)]^{1/2} \times 10^{-3} \ \text{radians}$$

where Antmun = modified refractivity at the antenna height

The initial launch angle of the ray, α, is set to the negative of the maximum allowed elevation angle, unless the antenna has a cosecant-squared pattern. (See NOSC TN 669.) In that case, the initial angle is the antenna elevation angle minus the vertical beamwidth.

If the refractivity at the antenna height is less than the M

Units array values at all heights above, then the transmitter is not within a duct. The angles defining ducts are set to zero.

If there is a duct, the launch angle above which no rays are trapped in the duct is

$$\alpha_d = [2\ (\text{Antmun} - \text{Ma})]^{1/2} \times 10^{-3} \quad \text{radians}$$

and the launch angle below which no rays are trapped in the duct is

$$\alpha_c = -\alpha_d \quad \text{radians}$$

The M-profile is next searched (in order of decreasing height) for the first height below Htop which has a refractivity of Ma. This level defines the bottom of the duct height (Hbottom). If no such height is found, the duct extends to the ground.

At this point the raytracing and plotting begins. The ray trace angle is set to α. The Antenna Pattern Subfunction (3.4.2.9) is referenced to find the antenna pattern factor at that angle and the result is stored as a variable (Patd). The plot range (Rplot) is then

$$\text{Rplot} = (\text{Patd})\ (\text{Frespc})$$

where Frespc = the free space range.

The Trace Subfunction (3.4.2.12) is called to trace and plot the ray launched at that angle. The next ray trace angle is found by translating α into screen units, using Subfunction FNS, adding .01, then translating it back into a true angle value using Subfunction FNT. If α is greater than the maximum allowed elevation angle, program control is passed to the Print Page Subfunction (3.4.2.23). Otherwise, the process repeats starting from the ray trace angle α.

3.4.2.6.3 Outputs

a. Minimum value of modified refractivity for the M profile (Mm)

b. Minimum refractivity at or above the radar height (Ma)

c. Height at which Ma occurs. This is the duct height for the antenna

d. The lower bound on the duct

e. The minimum angle below which all rays are reflected

f. Launch angle above which no rays are trapped in the duct (α_d)

g. Launch angle below which no rays are trapped in the duct (α_c)

h. Pointer to the antenna height entry in the ray tracing arrays

i. Array containing the height at which each layer starts (Hmrs)

j. Array containing 2×10^{-6} times the change in modified refractivity of each layer (Twodm)

k. Array containing 10^{-3} times the change in modified refractivity with height for each layer (Dmdh)

3.4.2.7 Surface Subfunction

3.4.2.7.1 Inputs

a. Environmental Data Set (See 3.4.7)

b. Cover System Data Set (See 3.4.9)

c. Ht - The transmitter or radar antenna height

3.4.2.7.2 Processing

This subfunction is called by the Cover Plot Subfunction. This subfunction first identifies the layer in the M-profile containing Ht. The arrays used for ray tracing are then filled starting at that height. Array Hmrs contains the height at which each layer starts (in order of increasing height) starting with Ht. Array Twodm contains 2 x 10^{-6} times the change in modified refractivity of each layer (ΔM) starting at Ht. Array Dmdh contains 10^{-3} times the change in modified refractivity with height starting at Ht. Each item in the Dmdh array is found by the following equation.

$$\mathrm{Dmdh}(i) = 10^{-3} \frac{\Delta M(i)}{\Delta H(i)}$$

where i = current layer

ΔM = change in modified refractivity through the layer

ΔH = change in height through the layer

The value of the modified refractivity at Ht is also calculated as

$$M_{Ht} = M(I) - \frac{\mathrm{Twodm}(1)}{2 \times 10^{-6}}$$

where

M(I) = the modified refractivity at the top of the layer which includes Ht.

Twodm(1) = the first item in array Twodm

The minimum value of the modified refractivity profile above Ht is found. If this minimum is less than M_{Ht} then the minimum angle not trapped is

$$Trap = [2(M_{Ht} - M_{min})]^{1/2} \times 10^{-3}$$

Otherwise, it is set to -1.57. The rms wave height in metres is

$$\bar{h} = 5.1 \times Wind^2 \times 10^{-3}$$

where

Wind = the wind speed in metres/sec

The antenna vertical beamwidth and elevation angle are converted to radians by multiplying them by 0.01745. The antenna pattern constants are then set. If the antenna pattern is a height-finder or sinx/x, the antenna factor is set such that the antenna is at half power at beamwidth

$$Antfac = \frac{1.39157}{\sin(\frac{BW}{2})}$$

where

BW = antenna half power beamwidth in degrees

For the cosecant-squared antenna patterns

$$Antfac = \sin(BW/2)$$

The maximum usable elevation angle (in radians) is set to avoid side lobes on the antenna. For omnidirectional and height finder antennas, it is set to $\pi/2$. For the sinx/x antennas, it is computed to be

$$\tan^{-1}\left[U/(1-U^2)^{1/2}\right] + \text{Antenna Elevation Angle}$$

where $U = \pi/Antfac$

If the pattern is a cosecant-squared antenna, the maximum usable angle is equal to the beamwidth plus the elevation angle, unless the antenna is aboard an airborne platform. Then the maximum usable angle is set equal to the elevation angle of the antenna. If the platform flag indicates that the platform is an aircraft, the Airborne Subfunction (3.4.2.6) is called next.

The effective earth constant in the first layer is calculated using the formula

$$K = \frac{1}{\left(1 + a\frac{dN}{dH}\right)}$$

where

a = mean earth radius (6371 km)

N = the refractivity of the atmospheric layer

H = height.

$a\frac{dN}{dH}$ is calculated from the formula

$$a\frac{dN}{dH} = \frac{\left(M_1 - M_o - \frac{h_1}{6.371} \right)}{h_1 / 6.371}$$

where

h_1 = height of the first layer

M_o = the value of the modified refractivity at the earth's surface.

M_1 = the modified refractivity at height, h_1.

The effective earth radius (in km) is

$$Ae = 6371\ K$$

where

$$K = \frac{1}{1 + a\frac{dN}{dH}}$$

The limiting grazing angle of the optical region (See NELC TN 3037) is

$$\psi = \frac{0.01957}{(f\ K)^{1/3}} \quad \text{radians}$$

where

f = frequency in MHz

The interference region is valid for the above grazing angle limit or when the path difference between the direct and sea reflected ray is 1/4 wavelength or greater. The approximate grazing angle where the path length difference between the direct and sea reflected ray is equal to the quarter wavelength is

$$\Psi 4 = \left(\frac{37.5}{f \; (3Ht^2 + 2Ht \; Ae \times 10^{3}} \right)^{1/2} \quad \text{radians}$$

The limiting grazing angle is set to be the smaller of the two angles, ψ or ψ_4.

The angular distance to the reflection point for a grazing angle of Ψ is

$$\gamma = -\psi + \left(\psi^2 + \frac{2Ht}{1000 \; Ae} \right)^{1/2} \quad \text{radians}$$

and the distance to the reflection point is

$$D1 = \gamma \, Ae$$

The path difference for a spherical earth is

$$Pds = 0.04188f \quad Ht^2 + \frac{D1^2 (Ae \times 10^3 + Ht) \times 10^3}{Ae^2}^{\;1/2} \quad \sin^2 \Psi \quad \text{radians}$$

If a trapping layer exists, then a loop commences to find a launch angle corresponding to an optical maximum, α, which penetrates the trapping layer. This is done by stepping through phase differences in increments of $2n\pi$ (a maximum) and of $2n\pi + \pi/16$ (equivalent to an elevation angle just above the maximum). The Alta Subfunction (3.4.2.10) is called to find the launch angle for each of these path differences. Once a launch angle (A1) which penetrates the trapping layer is found it is converted to screen units using the FNS Subfunction. the first non-trapped ray corresponding to an optical maximum or the quarter wavelength/grazing angle limit defines the lower limit of the optical region. When this angle has been determined the intermediate and diffraction field regions may be plotted. They are plotted the first time the Trace Subfunction is called as described in the following paragraph.

The rest of this subfunction is devoted to plotting the null pattern. It does this in phase difference increments of π (in a series of peaks to nulls). The launch angle corresponding to the next null or peak is found by using the Alta Subfunction. This angle is also converted into screen units and is called A2. An increment of the angle in terms of screen units (Ainc) is found to provide a display with adequate coverage between A1 and A2. The coverage is then plotted from A1 to A2 in increments of Ainc in the following manner:

Step 1. For each screen angle to be plotted the pattern propagation factor is found as well as the real launch angle for α, using the FNT Subfunction.

Step 2. The path difference assuming a flat earth is calculated to be

$$P_{df} = 0.04188\,(f)(Ht)(\sin\alpha) \quad \text{radians}$$

Step 3. The antenna pattern factor for the direct ray, Patd, is found for angle, α, using the Antenna Pattern Subfunction (3.4.2.9) and the surface roughness factor is found by calling the Surface Roughness Subfunction (3.4.2.8).

Step 4. If the flat earth flag indicates the flat earth approximation is sufficient, the divergence factor (Div) is set to 1, and the reflected ray's antenna pattern factor is calculated at angle $-\alpha$ by the Antenna Pattern Subfunction.

Step 5. If the spherical earth assumption is to be used, the angular distance to the reflection point is

$$\gamma = \left[\tan^2 \left(\frac{\alpha}{3}\right) - \frac{2\ Ht}{3Ae \times 10^3}\right]^{1/2} - \tan\left(\frac{\alpha}{3}\right)$$

Step 6. The grazing angle of the reflected ray is
$\Psi = \alpha + \gamma$

Step 7. The path difference is

$$Pds = 0.04188f \left[Ht^2 + \gamma^2\ Ae(Ae \times 10^3 + Ht) \times 10^3\right]^{1/2} \sin^2\Psi$$

Step 8. The divergence factor is

$$Div = \left(1 + \frac{\gamma^2}{\sin\Psi}\right)^{-1/2}$$

Step 9. The antenna pattern factor of the reflected ray, β, is calculated using the Antenna Pattern Subfunction.

where

$$\beta = -\alpha - 2\gamma \quad \text{radians}$$

Step 10. For both the spherical earth and flat earth approximations the pattern propagation factor is

$$F = \left[|Patd^2 + Dr^2 + 2(Patd)(Dr) \cos\theta_b| \right]^{1/2}$$

where

Dr = (Div)(Patr)(Ruf)

Patr = Antenna pattern for the reflected ray

Ruf = Surface roughness factor

θ_b = $P_{df}-\pi$ or $P_{ds}-\pi$

Step 11. The Trace Subfunction (3.4.2.12) is called to plot the coverage for a ray using the angle, α, and a range of the free space range times the pattern propagation factor.

Step 12 Repeat stops 1 through 11 until all increments are plotted.

Step 13. Once the coverage for all angles between A1 and A2 is plotted a series of checks is made:

a. If the plot ended at a peak and if the angular separation between this peak and the previous peak is less than 0.05 radian (screen angle), the Envelope Subfunction (3.4.2.11) is called.

b. If the plot ended at a null and if the spherical earth approximation is being used and the path difference calculations differ by less than 3/f from the flat earth approximation, then the flat earth flag is reset to indicate the flat earth assumption is to be used.

c. If the last angle plotted is greater than or equal to the maximum elevation angle to be plotted, then the Print Page Subfunction (3.4.2.23) is called. Otherwise, the next segment of the coverage diagram is plotted as explained in the discussion above.

3.4.2.7.3 Outputs

a. The minimum angle below which rays are trapped

b. The rms ocean wave height

c. The antenna pattern factor

d. The maximum elevation angle to be used in the plot

e. The effective earth constant in the first layer

f. The effective earth radius (in km)

g. The limiting grazing angle of the optical region (radians)

h. The coverage plot

i. Array (Hrms) containing the height at which each layer starts (in m)

j. Array (Twodm) containing 2×10^{-6} times the change in refractivity of each layer

k. Array (Dmdh) containing 10^{-3} times the change in modified refractivity with height for each layer

3.4.2.8 Surface Roughness Subfunction

3.4.2.8.1 Inputs

a. Frequency

b. Rms ocean wave height

c. Grazing angle of the reflected ray (Ψ)

3.4.2.8.2 Processing

This subfunction is called by the Surface and Envelope Subfunctions. This subfunction computes the surface roughness factor. (See NOSC TN 669).

Step 1. If $-2(0.2094 f \bar{h} \sin\Psi) < -0.95555$, go to Step 3.
where $\bar{h}$ = rms ocean wave height

Step 2. Roughness factor = $\exp[-2(0.2094f\bar{h}\sin\psi)]$
Terminate the algorithm.

Step 3. If $0.2094f\bar{h}\psi > 0.26$, go to Step 4.
Roughness factor = $0.5018913 - \left[0.2090248 - (\frac{\psi}{2} - 0.55189)^2\right]^{1/2}$
Terminate the algorithm.

Step 4. Roughness factor - 0.15.
Terminate the algorithm.

Control is then returned to the calling subfunction

3.4.2.8.3 Outputs

Roughness Factor value (Ruf).

3.4.2.9 Antenna Pattern Subfunction

3.4.2.9.1 Inputs

a. Type of antenna pattern as listed in Table 3.4.9-2.

b. Elevation angle of the direct ray.

c. Elevation angle of antenna

d. Elevation angle of the reflected ray (surface systems only).

3.4.2.9.2 Processing

This subfunction is called by the Airborne, Envelope, and Surface Subfunctions. This routine is used for both air and surface system antenna patterns. The following algorithm is used for all antenna types. (See NOSC TN 669.)

Step 1. Patfac = 1.
If the antenna is omnidirectional, terminate the algorithm.

Step 2. If the antenna is a height-finder set the elevation angle of the antenna to the angle of the direct ray.

Step 3. Locate the ray with respect to the center of the antenna.
Apat = elevation angle of the antenna - angle of the ray being traced.

Step 4. If the antenna type is cosecant-squared, go to Step 6.

Step 5. If $|Apat| < 1 \times 10^{-6}$ terminate the algorithm. Otherwise, find the antenna pattern function for the ray of a $\frac{\sin x}{x}$ or height-finder antenna.

$$\text{Patfac} = \frac{\sin\left[\text{Antfac}\ (\sin(\text{Apat}))\right]}{\text{Antfac}\ \left[\sin(\text{Apat})\right]}$$

Terminate the algorithm.

Step 6. If $|Apat| \leq \frac{BW}{2}$ then terminate the algorithm.
where $BW = 1.745 \times 10^{-2}$ times vertical beamwidth of the antenna in radians.

Step 7. $$\text{Patfac} = \frac{\text{Antfac}}{\sin\ (|\text{Antfac}|)}$$

Terminate the algorithm.

Control is then returned to the calling subfunction.

3.4.2.9.3 Outputs

Antenna pattern factor for a given ray.

3.4.2.10 Alta Subfunction

3.4.2.10.1 Inputs

a. Flag indicating whether the flat earth approximation or the spherical earth approximation is to be used

b. The phase at the desired solution (θ)

c. The path difference phase for a direct ray launch angle of $\alpha(\theta_b)$

d. The path difference phase for a direct ray launch angle of Alsave

e. The initial launch angle of the ray (α)

f. Alsave

g. The effective earth radius (in km)

h. Ht - the transmitter or radar antenna height

3.4.2.10.2 Processing

This subfunction is called from the Surface Subfunction. This subfunction uses Newton's iterative method to find the direct ray launch angle which has a phase difference of θ with the interfering reflected ray. If A is the launch angle and P is the phase difference, the next iteration for the launch angle is

$$A' = A - \frac{\Delta \; - \theta}{\frac{\Delta P}{\Delta A}}$$

where the slope $\frac{\Delta P}{\Delta A}$ is computed from the previous two iterations on A.

$$\Delta\theta = \theta_b - \theta.$$

The flat earth phase difference is computed for each iteration. It is

$$P_{df} = 0.04188f(Ht)(\sin A)$$

If the flat earth flag indicates that a spherical earth calculation is to be used instead, the angular distance (as viewed from the center of the effective earth) from the antenna to the reflection point is

$$\gamma = \left[\left(\frac{\tan A}{3}\right)^2 - \frac{2\ Ht}{Ae \times 10^3}\right]^{1/2} - \frac{\tan A}{3}$$

The grazing angle of the reflected ray is

$$\psi = A + \gamma^2$$

And the path difference between the direct and reflected rays is

$$P_{ds} = 0.04188f\ \sin^2\psi \left[Ht^2 + \gamma^2 Ae \left(Ae \times 10^3 + Ht\right) \times 10^3\right]^{1/2}$$

Both the flat earth and spherical earth approximations assume a distant target. The value of the total phase difference between the direct and reflected ray is then calculated using

$\theta = P_{ds} - \pi$ or $\theta = P_{df} - \pi$

The iteration is repeated for a maximum of ten times or until a direct ray launch angle is found with a corresponding phase within 0.031416 radian of θ. Control is then returned to the calling subfunction.

3.4.2.10.3 Outputs

Elevation angle (in radians) which results in a phase difference of θ.

3.4.2.11. Envelope Subfunction

3.4.2.11.1 Inputs

a. The flat earth flag.

b. The initial launch angle in the envelope region.

c. Ht - The transmitter or radar antenna height.

d. The effective earth radius (km).

e. The antenna type flag.

f. The free space range.

g. The maximum elevation angle.

3.4.2.11.2 Processing

This subfunction is called by the Surface Subfunction. The envelope portion of the plot is accomplished in angular increments of 0.01 radian until the true angle reaches the maximum elevation angle.

Then the Print Page Subfunction is called.

The plotting of each angle is performed by the following procedure: The antenna pattern factor is calculated using the Antenna Pattern Subfunction (3.4.2.9) for the direct ray at angle α. If the flat earth approximation is to be used, the roughness factor and antenna pattern are calculated using the Surface Roughness (3.4.2.8) and Antenna Pattern Subfunctions. The pattern propagation factor is then calculated as described below.

If the spherical earth approximation is to be used, the angular distance to the reflection point is

$$\gamma = \left[\frac{\tan^2 \alpha}{9} - \frac{2Ht}{3Ae \times 10^3}\right]^{1/2} - \frac{\tan \alpha}{3}$$

If $\frac{\alpha}{\gamma} > 200$, the flat earth flag is reset to indicate that the flat earth approximation is adequate. The limiting grazing angle of the optical region is found next.

$$\psi = \gamma + \alpha$$

The launch angle for the reflected ray is

$$\beta = -\alpha - 2\gamma$$

and the divergence factor is

$$\left[Div = 1 + \frac{2}{\sin\psi}\right]^{-1/2}$$

The surface roughness factor and antenna pattern factor are then calculated for the reflected ray using the Surface Roughness and Antenna Pattern Subfunctions.

The pattern propagation factor (F) is calculated as the envelope of the maxima of the radar system. Hence the path difference between the direct and reflected ray is not a factor in the calculation

$$F = \left[|Patd^2 + (Patr^2)\ (Dr^2) + 2Patr\ (Dr)|\right]^{1/2}$$

where

Dr = (Div)(Ruf)

Patd = (Div)(Patfac)(Ruf), the antenna pattern factor for the direct ray

Patr = the antenna pattern factor for the reflected ray

Ruf = the surface roughness factor

The Trace Subfunction is called to plot the coverage for a ray of launch angle α and range of F times the free space range.

3.4.2.11.3 Outputs

Coverage plot using the envelope of optical maxima.

3.4.2.12 Trace Subfunction

3.4.2.12.1 Inputs

a. Initial launch angle of the ray

b. Ht - The transmitter or radar antenna height

c. Platform type flag

d. Maximum launch angle in the trapped region (α_d)

e. Minimum launch angle in trapped region (α_c)

3.4.2.12.2 Processing

This subfunction is called by the Airborne, Surface Trace, and Surface Subfunctions. This subfunction first examines the platform type flag, and if the system is on a surface ship, the Surface Trace Subfunction (3.4.2.19) is called.

The following procedure is used for airborne platforms:

Step 1. If the launch angle is within the trapping region the Trapped Subfunction (3.4.2.13) is called.

Step 2. If the launch angle is less than α_c the Downgoing Subfunction (3.4.2.14) is called.

Step 3. If the launch angle is greater than α_d the Upgoing Subfunction (3.4.2.16) is called.

The Trapped Subfunction is called next.

3.4.2.12.3 Outputs

None

3.4.2.13 Trapped Subfunction

3.4.2.13.1 Inputs

a. Free space range

b. Ht - the transmitter or radar antenna height

c. Maximum launch angle in the trapped region (α_d)

d. Minimum launch angle in the trapped region (α_c)

e. Maximum height in the trapped region

f. Minimum height in the trapped region

g. Array containing 10^{-3} times the change in modified refractivity with height (Dmdh)

3.4.2.13.2 Processing

This subfunction is called by the Trace Subfunction. In the trapping layer the radar range (Rd) is assumed to be twice the free space range. The coverage in this area is bounded by the critical angles and the height of the top and bottom of the layer as shown in Figure 3.4.2-2. The coverage diagram is developed as a series of ten rays at constant heights. The height increment between rays is

$$\Delta h = \frac{Htop-Hbottom}{10}$$

where

Htop = maximum height in the trapped region

Hbottom = minimum height in the trapped region

The ray at the antenna height is plotted starting with a range of zero

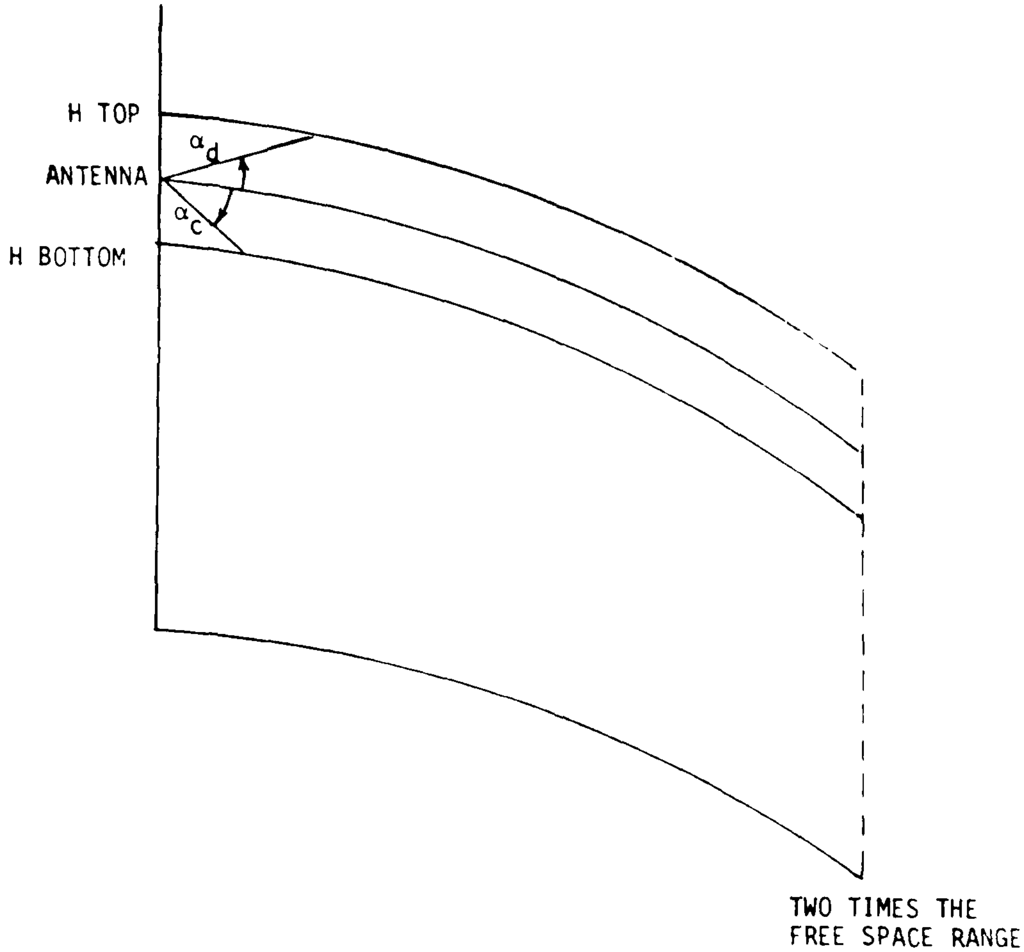


FIGURE 3.4.2-2 TRAPPING LAYER COVERAGE

to twice the free space range.

Each ray above Ht starts at a range of

$$D1 = D0 + \frac{A1 - A0}{Dmdh(i)}$$

where

D0 = the starting range of the previous ray

A0 = Angle of a ray which started from Ht with a launch angle of δ_d

A1 = Angle for that ray at the present height

$$A1 = -\left[A0^2 - 2\Delta h \ Dmdh(i) \times 10^6\right]^{1/2}$$

Dmdh(i) = the ith item in the Dmdh array

and ends at a range of Rd. Each plot below the antenna starts at a range of

$$D1 = D0 + \frac{A1 - A2}{Dmdh(i)}$$

where

A2 = angle of a ray which started from Ht with a launch angle of

δ_c.

The Rayplot Subfunction (3.4.2.22) is called next.

3.4.2.13.3 Outputs

Coverage plot in the trapped region.

3.4.2.14 Downgoing Subfunction

3.4.2.14.1 Inputs

a. Launch angle of the ray

b. Range covered by the ray thus far (initially set to zero)

c. Index for the ray trace arrays

d. The maximum ground range to be plotted for this ray (Rplot)

e. Array containing the height at which each layer starts (Hmrs)

f. Array containing 2×10^{-6} times the change in refractivity of each layer (Twodm)

g. Array containing 10^{-3} times the change in modified refractivity with height for each layer (Dmdh)

h. Maximum range of plot (Rmax)

3.4.2.14.2 Processing

This subfunction is called by the Trace Subfunction. This subfunction traces downgoing rays. The first index for the ray trace arrays is decremented. (The next lower layer is the one of interest.) If the angle of the ray at the top of the layer is designated A0, the angle of the ray at the bottom of the layer is

$$A1 = \left[A0^2 - Twodm(i)\right]^{1/2}$$

where

i = index for the ray trace arrays

If the radicand ever goes negative, control is transferred to the Ray Minimum Subfunction (3.4.2.15). Otherwise, the ground range traveled in the path segment is

$$Dx = (A1 - A0)/Dmdh(i)$$

If this range increment causes the total range traveled by the ray to exceed Rplot, the Final Range Increment Subfunction (3.4.2.17) is called. Otherwise, an increment is added to the range, the height is set to Hmrs (i) and Rayplot Subfunction (3.4.2.22) is called. If the range increment causes the total range to exceed Rmax, this increment is plotted by calling the Rayplot Subfunction, and control is passed back to the Airborne Subfunction (3.4.2.6). Afterward the index is again decremented. If ground level is reached, the index is reinitialized to be at zero range at the antenna height. Control is then passed back to Airborne Subfunction. If there is yet another layer, the ray angle A0 is set to A1 and the process repeats.

3.4.2.14.3 Outputs

a. Plot of a ray starting at launch angle A0 until it covers a ground range of Rplot, Rmax, or reaches ground level.

b. Height of the ray at any given point in the calculation

c. Range of the ray at any given point in the calculation

3.4.2.15 Ray Minimum Subfunction

3.4.2.15.1 Inputs

a. Launch angle of the ray

b. Index for the ray trace arrays

c. Range traveled by the ray thus far

d. Total range to be plotted by this ray (Rplot)

e. Array containing the height at which each layer starts (Hmrs)

f. Array containing 10^{-3} times the change in modified refractivity with height for each layer (Dmdh)

g. Maximum range of plot (Rmax)

3.4.2.15.2 Processing

This subfunction is called by the Downgoing Subfunction. The range to the ray minimum from the range traveled thus far is

$$Dx = A0/Dmdh(i)$$

where

A0 = launch angle of ray

i = current index value

If this range increment would cause the range to exceed the total range, Rplot, of the ray, the Final Range Increment Subfunction is called. Otherwise, the height increment to the ray minimum is

$$\Delta h = \frac{-500A0^2}{Dmdh(i)}$$

The Rayplot Subfunction (3.4.2.22) is called next to plot the ray at its new height and range. The ray angle, A0, is then set to zero. The start flag is set to the current layer and the Upgoing Subfunction is called.

3.4.2.15.3 Outputs

a. Layer in which the ray reaches a minimum

b. Distance traveled thus far

c. Current Ray angle

d. Current Ray height

e. Height of ray minimum

3.4.2.16 Upgoing Subfunction

3.4.2.16.1 Inputs

a. Array index for the layer in which the ray starts

b. Launch angle of the ray

c. Current ray height

d. Current distance traveled by the ray

e. Maximum distar to be plotted for this ray (Rplot)

f. Maximum range of plot (Rmax)

g. Maximum height of plot (Hmax)

h. Total number of layers in ray tracing arrays

i. Array containing the height at which each layer starts (Hmrs)

j. Array containing 10^{-3} times the change in modified refractivity with height for each layer (Dmdh).

3.4.2.16.2 Processing

This subfunction is called by the Trace, Negative Launch Angle, and Ray Minimum Subfunctions. The angle at the next boundary of the layer is

$$A1 = \left[A0^2 + 2Dmdh(i)(Hmrs(i+1) - h) \times 10^3\right]^{1/2}$$

where

h = current ray height

The range covered by the ray in the current layer is

$$\Delta D = (A1-A0)/Dmdh(i)$$

If this range increment would result in a total range covered by the ray which is greater than Rplot, then the Final Range Increment Subfunction is called. Otherwise, the height of the ray is the height of the next refractivity layer and the range increment is added to the range covered by the ray. The Rayplot Subfunction is called to plot this ray segment. The ray angle, A0, is set to A1. If the height or range exceeds the limits of the plot, the index is changed to correspond with the antenna height and control is passed back to the calling subfunction. Otherwise, the index, i, is incremented. If the new layer is the highest layer in the M profile, the Final Range Increment Subfunction is called to finish the plot. Otherwise, the process repeats to plot the next ray segment.

3.4.2.16.3 Outputs

a. Plots the segment of a ray with a positive launch angle

b. Current angle of the ray

c. Current index for the layer in which the plot ended

d. Distance traveled by the ray

3.4.2.17 Final Range Increment Subfunction

3.4.2.17.1 Inputs

a. Maximum ground range to be plotted for the ray (Rplot)

b. Current range of the ray (Rx)

c. Launch angle of the ray (A0)

d. Array containing 10^{-3} times the change in modified refractivity with height for each layer (Dmdh)

e. Index for the current layer in the M profile (i)

f. Current height of the ray (h)

g. Ht - The transmitter or radar antenna height

3.4.2.17.2 Processing

This subfunction is called by the Downgoing, Negative Launch Angle and Upgoing Subfunctions. The angle of the ray when it has traveled a total distance, Rplot, is

$$A1 = A0 + Dmdh(i)\ (Rplot-Rx)$$

The height of the ray when it reaches a distance Rplot is

$$h' = h + 500\ (A1^2 - A0^2)/Dmdh(i)$$

The Rayplot Subfunction is then called to plot the final ray segment at height h' and range Rplot. The plot pointer is moved back to zero range and height Ht. Finally this subfunction returns control to the subfunction which called it.

3.4.2.17.3 Outputs

Plot of final segment in a ray trace.

3.4.2.18 *Negative Launch Angle Subfunction*

3.4.2.18.1 Inputs

a. Current height of the ray (h)

b. Launch angle of the ray (A0)

c. Current distance traveled by ray (Rx)

d. Maximum ground range to be plotted for this ray (Rplot)

e. Effective earth radius (Ae)

f. The rate of change of refractivity with height in the lowest layer (Dmdh (1))

g. The total number of layers

h. Ht - The transmitter or radar antenna height

3.4.2.18.2 Processing

This subfunction is called by the Surface Trace Subfunction. The range at which a negatively launched ray reaches a minimum is

$$Rtm = |(A0)(Ae)|$$

If Rplot is greater than twice this range, then the range of the ray is set to 2 Rtm and the Rayplot Subfunction (3.4.2.22) is called to plot the ray at this range and at its original height. If there is only one refractivity layer, then the Final Range Increment Subfunction is called. Otherwise, the launch angle is set to the absolute value of itself and the Upgoing Subfunction is called.

If Rplot is less than Rtm (the ray does not reach a minimum) then the angle of the ray when it reaches its maximum range is calculated as

$$A1 - A0 + Dmdh(1)\ (Rplot - Rx) \times 10^{-3}$$

and the height at that point is

$$h' = h + \frac{A1^2 - A0^2}{Dmdh(1) \times 10^{-6}}$$

The Rayplot Subfunction is called to plot the ray at distance Rplot and height h'. The plot cursor is returned to height Ht and this subfunction terminates.

If Rplot is greater than Rtm but less than 2 Rtm, then the ray's minimum height is found from

$$A1 = A0 + (Rtm)\,(Dmdh(1)) \times 10^{-3}$$

$$h' = h + \frac{A1^2 - A0^2}{2Dmdh(1) \times 10^{-6}}$$

The Rayplot Subfunction is called to plot the ray at distance Rtm and height h'.

The launch angle of the ray is then set to zero. The height of the ray when it reaches a distance Rplot is found from

$$A1 = (Rplot - Rtm)\,Dmdh(1) \times 10^{-3}$$

$$h' = h + \frac{A1^2}{2\,Dmdh(1) \times 10^{-6}}$$

The Rayplot Subfunction is called to plot the ray at range Rplot and height h'. The plot cursor is returned to height Ht. Control is then transferred to the Final Range Increment Subfunction (3.4.2.17).

3.4.2.18.3 Outputs

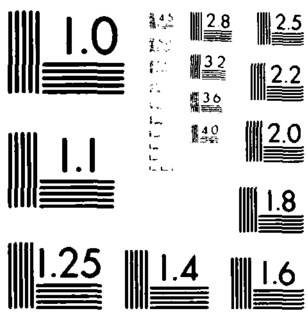
Plot of the ray segment which has an initial negative angle and has a minimum height above the earth's surface.

3.4.2.19 Surface Trace Subfunction

3.4.2.19.1 Inputs

AD-A092 297 MEGATEK CORP SAN DIEGO CA F/6 20/14
INTEGRATED REFRACTIVE EFFECTS PREDICTION SYSTEM (IREPS): PROGRA--ETC(U)
JUL 80 H V HITNEY, E W PASAHOW, M E O'BRIAN N00123-78-C-0043
UNCLASSIFIED R2018-059-IF-2 NOSC-TD-365 NL

2 of 5
AD
A092297



MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS 1963 A

a. Launch Angle (A0)

b. Maximum ground range to be covered by ray (Rplot)

c. Effective earth radius (Ae)

d. Diffraction flag indicating whether diffraction field calculations are to be ignored

e. Environmental Data Set (see 3.4.7)

f. Cover System Data Set (see 3.4.9)

g. Effective earth factor in the first layer (K)

h. Direct ray antenna pattern factor

i. Array containing 10^{-3} times the change in modified refractivity with height for each layer (Dmdh)

j. Current height of the ray (h)

k. Array containing the height at which each layer starts (Hmrs)

3.4.2.19.2 Processing

This subfunction is called by the Trace Subfunction. The first time this subfunction is called is for the initial ray which defines the optical region's lower (angular) limit. All rays with lower launch angles would be in the intermediate region or below the horizon ray. After the initial ray is traced the diffraction field flag is set and all subsequent rays are traced, by calling the Negative Launch Angle Subfunction (3.4.2.18) or Upgoing Subfunction, as appropriate. If the launch angle is less than zero, the range at which the ray would reach its minimum height (assuming it is not intercepted by the earth) is

$$Rtm = -A0\ Ae$$

The range at which it reaches its original height and has the negative of its original angle is

$$Rht = 2Rtm$$

If range Rht is larger than Rplot, the ray is traced to range Rplot in the following manner:

The height at the ray minimum distance Rtm is

$$h' = h + \frac{A0^2 \times 10^3}{2Dmdh(i)}$$

where

i = layer index

When the ray reaches distance Rplot it will be at angle A1 where

$$A1 = (Rplot - Rtm)\ Dmdh(1) \times 10^{-3}$$

and at height

$$Hr = h' + \frac{A1^2 \times 10^3}{2Dmdh(1)}$$

If the ray range, Rplot, is larger than Rtm, then the height at Rplot is found in the following manner:

When the ray reaches distance Rplot, it will be at angle A1 where

$$A1 = A0 + Dmdh(1)\ Rplot$$

The height of the ray at range Rplot is given by

$$Hr = Ht + \frac{(A1^2 - A0^2) \times 10^3}{2Dmdh(I)}$$

If Rplot is greater than Rht, the range is set to Rht and A0 set to -A0. The trace is then continued through the layers to range Rplot as follows: The ground distance the ray has traveled when it reaches layer i+1 is

$$R_{i+1} = R_i + \frac{A1-A0}{Dmdh(i)}$$

The trace continues upward through the layers until the ray reaches the last layer or travels a distance greater than Rplot in a layer. If R_{inc} is the range increment the ray must travel to get to Rplot in this layer, the angle it will have at that range is

$$A1 = A0 + R_{inc}\, Dmdh(N) \times 10^{-3}$$

where

N = index number of the layer

and the height it will have is

$$Hr = Hmrs\,(N) + \frac{(A1^2 - A0^2)}{2Dmdh(N) \times 10^{-6}}$$

Once the final height, Hr, at range Rplot for the initial ray has been determined the diffraction field and intermediate regions can be plotted. They are plotted using the fact that the pattern propagation factor is a constant along the ray. This ray defines the maximum range of the optical interference region at each height on its trace. The horizon and diffraction field minimum ranges can easily be calculated for all heights up to Hr and the loss at these diffraction field minimum ranges obtained from the Diffraction Region Subfunction. The plot range for any height can be obtained by interpolation when the diffraction field loss is greater than the free space loss of the system or by finding the range where the diffraction field loss equals the free space loss when this loss exceeds the threshold.

The following constants are calculated in order to plot the diffraction/intermediate regions.

The horizon range for height Ht is

$$Horizon_{Ht} = 3.572\ (K\ Ht)^{1/2}$$

The horizon range for Hr

$$Horizon_{Hr} = 3.572\ (K\ Hr)^{1/2}$$

The minimum range of the diffraction field for a target at the ground is

$$Dmin = 230.2\ \left(\frac{K^2}{f}\right)^{1/3} + Horizon_{Ht}$$

The non-range dependent part of the free space path loss is

$$Fsterm = 32.45 + 8.686 \ln(f)$$

where

f = frequency in MHz

The pattern propagation factor in dB is

$$Loss_p = -20\log(|Patd|)$$

The Diffraction Region Subfunction (3.4.2.20) is then called to find the duct type and the parameters necessary to calculate the loss in the diffraction field region.

The following paragraphs describe computing the coverage for heights and ranges of the target in the diffraction region. A height increment is found which covers the resolution of the plot. If there are N possible points (plotter resolution) in the vertical direction and h is the height of the axis (in metres), then

$$h_{inc} = \frac{h}{N}$$

The initial height is set to the maximum of hmin, the minimum height to be considered in the diffraction region (see Diffraction Region Subfunction), and h_{inc}. These heights are then incremented until the top of the diffraction region is reached. If a ground-based duct exists then h_{inc} will be the lesser of h_{inc} and D/15 where D is the duct height. If a strong evaporation duct exists then h_{inc} is the lesser height interval of h_{inc} and hlm/5, where hlm is defined in the Diffraction Region Subfunction.

For any height which is greater than Ht a ray trace is carried out to that height to find the ground range. This is done in a manner similar to the calculation of Hr:

The range at which a negative ray reaches the antenna height again is

$$R0 = 2Ae\ A0$$

Its angle, A1 is

$$A1 = -A0$$

If A_i is the ray angle at height h_i range R_i in layer i, the ray angle at layer i+1 is

$$A_{i+1} = A_i^2 + 2(h_{i+1} - h_i)Dmdh(i) \times 10^{-6}$$

and the ray range is

$$R_{i+1} = R_i \frac{A_{i+1} - A_i}{Dmdh(i) \times 10^{-3}}$$

These equations are iterated until desired height is reached. The range at this height is stored as the optical range Ir. If the height is less than the Ht, Ir is set to 0. The plot pointer is moved to the position for range Ir at the ray height. The Target Height Gain Subfunction (3.4.2.21) is called to calculate the height gain in the duct for that height. Newton's iteration method is carried out to find at what distance the diffraction region loss is equal to the free space loss. The iteration is continued until the range is known to be within one thousandth of the maximum range of the plot or for a maximum of ten times.

The difference between the diffraction loss (at height h and range R) and the optical loss at the free space range is

$$C = \Delta Loss - F(h) + 10\log(R) + Att\ R$$

where

ΔLoss = difference between non-range dependent terms of the diffraction loss and the free space loss of the system

F(h) = the height gain for height h

Att = the attenuation in the diffraction region

and

$$\frac{dC}{dR} = \frac{4.343}{R} + Att$$

So if C and $\frac{dC}{dR}$ are known for a given range, R, then next iteration on R is found by

$$R_{i+1} = R_i - C/\frac{dC}{dR}$$

using Newton's method. The initial range is set at 10 km for the first height to be plotted. Thereafter the previous range found by iteration is saved as the starting range for the next height.

Once the range, R_{i+1} is found, it must be checked to see if it is truly in the diffraction region. The diffraction region for target height h starts at:

$$D_h = D_{min} + 3.572\ (Kh)^{1/2}$$

If R_{i+1} is greater than D_h, a ray is plotted at constant height h as in the last paragraph of this subfunction. If R_{i+1} is less than that value, then the range is found using Kerr's method of "Bold Interpolation":

The loss at the minimum range in the diffraction region is

$$Loss_D = Diffac - F(h) + 10\log(D_h) + (Att)(D_h)$$

Where Diffac = the non-range dependent part of the diffraction loss

F(h) = the height gain function at height h

The ratio of Rplot the horizon range at height Hr is

$$\text{Ratio} = \frac{\text{Rplot}}{3.572\left[(KHr)^{1/2} + (KHt)^{1/2}\right]}$$

The minimum range in the optical region is taken to be

$$\text{Rmin} = (\text{Ratio})(\text{Dh})$$

The optical loss at that point is

$$\text{Loss}_O = 32.45 + 20\log(f) + 20\log\,(R_{FSP})(\text{Ratio}) - \text{Loss}_p$$

where R_{FSP} = the free space range

The rate of change of loss in dB with range in the intermediate region is then

$$\frac{dL}{dR} = \frac{\text{Loss}_O - \text{Loss}_D}{R_{min} - D_h}$$

The minimum detection threshold of the system is

$$L_{FSP} = 32.45 + 20\log(f) + 20\log(R_{FSP})$$

So the ground range where this loss occurs is

$$R_{df} = \text{Rmin} + \frac{(\text{Loss}_O - L_{FSP})}{\frac{dL}{dR}}$$

A ray is plotted at constant height h, from the optical range

Ir to range R_{df} using the Rayplot Subfunction. If the diffraction range R_{df} is less than the optical range or if height h is greater than height Hr, the Diffraction Flag is set to indicate that the diffraction region has been exceeded, and the Trace Subfunction is referenced to perform an optical region calculation for the same launch angle and range. Otherwise the height is incremented by h_{inc} and the diffraction region calculations are repeated for that height.

3.4.2.19.3 Outputs

a. Coverage for the intermediate region

b. Coverage for the diffraction region

3.4.2.20 Diffraction Region Subfunction

3.4.2.20.1 Inputs

a. M units array

b. Ht - The height of the transmitter or radar antenna

c. Hr - The height of Rplot for the first range in the optical region

d. Frequency in MHz (f)

e. Evaporation duct height (δ)

f. Array containing the height at which each layer starts (Hmrs)

3.4.2.20.2 Processing

This subfunction is called by the Surface Trace Subfunction. A search is made of the M unit array to find if a duct exists which includes Ht. The top of the duct is a point at which the M profile reaches a minimum. See Figure 3.4.9-2. The bottom of the duct can be computed using the formula

$$H_{bottom} = H_j + \frac{M_{(min)} - M_{(j)}}{Dmdh(j)}$$

where j = the layer at which $\frac{dM}{dH}$ went positive.

The "ground based" duct approximation is made if the Ht is within a duct as described above.

If a ground-based duct containing Ht as described above is found, height-gain factors are calculated using empirical models developed at NOSC (see NOSC TN 669). These computations are in terms of $\frac{Ht}{D}$. (If $\frac{Ht}{D}$ is less than 0.1, this term is set to 0.1.)

The transmitter/radar height-gain in dB is

$$F(Zt) = 8.686 \ln \left(\sin \frac{\pi Ht}{D}\right) \qquad 0.1 \leq \frac{Ht}{D} \leq 0.8$$

$$F(Zt) = 1.55 \left(\frac{Ht}{D}\right)^{-5.57} - 10 \qquad 0.8 < \frac{Ht}{D}$$

The receiver/target height-gain is given in terms of $\frac{Hr}{D}$. (If $\frac{Hr}{D}$ is less than 0.1, this term is set to 0.1.) The receiver/target height-gain in dB is

$$F(Zr) = 8.686 \ln \left(\sin \frac{\pi Hr}{D}\right) \qquad 0.1 \leq \frac{Hr}{D} \leq 0.8$$

$$F(Zr) = 1.55 \left(\frac{Hr}{D}\right)^{-5.57} -10 \quad 0.8 < \frac{Hr}{D}$$

The non-range dependent loss in the diffraction region is found

$$Difac = 65 + Tlfq - F(Zt) - F(Zr)$$

where

$$Tlfq = 4.343 \ln(f)$$

The attenuation rate in the diffraction region is set to 0.012 dB/km.

If no duct (as described above) is found, the height-gain factors for an evaporation duct are computed. The model used to calculate the height-gain functions for the evaporation duct uses a curve fit to a single-mode waveguide solution at 9.6 GHz. To use this model at other frequencies, the ranges must be scaled by

$$Rfac = 4.705 \times 10^{-2} f^{1/3}$$

and heights must be scaled by

$$Zfac = 2.214 \times 10^{-3} f^{2/3}$$

The minimum target height is

$$Hmin = (Zfac)^{-1}.$$

After Rfac and Zfac are calculated, the scaled Ht, Hr, and evaporation duct heights are computed using Zfac. These are Zt, Zr, and Del, respectively.

$$Zt = \frac{1}{Zfac} \qquad \frac{1}{Zfac} > (Ht)(Zfac)$$
$$= (Ht)(Zfac) \qquad \text{otherwise}$$

$$Zr = \frac{1}{Zfac} \qquad \frac{1}{Zfac} > (Hr)(Zfac)$$
$$= (Hr)(Zfac) \qquad \text{otherwise}$$

$$Del = \delta\, Zfac$$

where

δ = evaporation duct height (see 3.4.7.16.2)

If the scaled duct height is greater that 23.3 metres, it is reset to 23.3 metres.

If the duct height is between 10.24 and 23.3 meters (a well trapped mode), the following parameters are calculated for the scaled duct height.

$$C1 = -0.1189\ Del + 5.5495$$
$$C3 = 0.095185 \left\{ \left[1.3291 \sin(0.218(Del - 10)^{0.77}) \right] + 0.2171 \ln(Del) \right\}$$
$$C4 = 87 - \left[313.29 - (Del - 25.3)^2 \right]^{1/2}$$

$$C5 = \frac{Fmax}{(Hlm)^{C6}}$$

$$C6 = \frac{(Hlm)(Slope)}{Fmax}$$

$$C7 = 49.4 \exp[-0.1699(Del-10)] + 30$$

where

$$Hlm = 4 \exp[-0.31\ (Del-10)] + 6$$

$$slope = \frac{1.5(C1)(C3)\ Hlm^{1/2}}{\tan(C3\ Hlm^{3/2})}$$

$$Fmax = C1 \ln \left[\sin(C^3\ Hlm^{3/2})\right] + C4 - C7$$

The height-gains are then computed. The Ht height-gain is

$$F(Zt) = C1 \ln \left[\sin \left[C3 \left(\frac{Zt}{4.72}\right)^{3/2}\right]\right] + C4 \qquad Zt \leq 4.7\ Hlm$$

$$F(Zt) = C5 \left(\frac{Zt}{4.72}\right)^{C6} + C7 \qquad Zt > 4.72\ Hlm$$

The Hr height-gain is

$$F(Zr) = C1 \ln \left[\sin \left[C3 \left(\frac{Zr}{4.72}\right)^{3/2}\right]\right] + C4 \qquad Zr \leq 4.72\ Hlm$$

$$F(Zr) = C5 \left(\frac{Zr}{4.72}\right)^{C6} + C7 \qquad Zr > 4.72\ Hlm$$

If the scaled evaporation duct height is less than 10.24m, the following parameters are computed.

$$C1 = 0.211864\ C2 \left[-2.20 \exp(-0.244\ Del) + 17\right]$$

$$C2 = [4.062361 \times 10^4 - (Del + 4.4961)^2]^{1/2} - 201.0128$$

$$C3 = 0.211864\ C4\left[-33.9\ \exp(-0.517\ Del) - 3\right]$$

$$C4 = [1.43012 \times 10^4 - (Del + 5.32545)^2]^{1/2} - 119.569$$

$$C5 = 41\ \exp(-0.41\ Del) + 61$$

Then the height-gain functions for Ht and Hr are calculated

$$F(Zt) = C1\left(\frac{Zt}{4.72}\right)^{C2} + C3\left(\frac{Zt}{4.72}\right)^{C4} + C5$$

$$F(Zr) = C1\left(\frac{Zr}{4.72}\right)^{C2} + C3\left(\frac{Zr}{4.72}\right)^{C4} + C5$$

For all scaled evaporation duct heights, the attenuation rate in dB/km is found as follows:

$$At = 92.516 - \left[8608.7593 - (Del - 20.2663)^2\right]^{1/2}$$

If At is less than 9×10^{-4}, it is set to 9×10^{-4}. The attenuation is then

Attenuation = (Rfac)(At) in dB/km.

The excitation factor in dB (Tlm) is computed

$$Tlm = 216.7 + 1.5526\ Del \qquad Del \le 3.8$$

$$Tlm = 222.6 - 1.1771\ (Del - 3.8) \qquad Del > 3.8$$

and the non-range dependent loss in the diffraction region is computed using the formula

$$Difac = 51.1 + Tlm - F(Zt) - F(Zr) + 4.343\ \ln\ (Rfac)$$

Control is then transferred to the Target Height Gain Subfunction.

3.4.2.20.3 Outputs

a. Flags if the diffraction zone calculations were done assuming an evaporation duct or a ground based duct

b. The non-range dependent portion of the loss in the diffraction region

c. The attenuation rate (dB/km) in the diffraction region.

d. Parameters used in calculating the height gain for the evaporation duct

e. Height scaling factor

f. Ground based duct height

g. Scaled evaporation duct height

h. The minimum target height to be considered

3.4.2.21 Target Height Gain Subfunction

3.4.2.21.1 Inputs

a. Height gain parameters for this duct

b. Duct type (evaporation or ground based)

c. Height scaling factor (Zfac)

d. Duct height (ground based duct only)

e. Scaled duct height for an evaporation duct

f. Target height

g. Boundary in evaporation duct calculations

h. Evaporation duct parameters from the Diffraction Region

Subfunction.

3.4.2.21.2 Processing

This subfunction is called by the Diffraction Region or Surface Trace Subfunctions. If the duct type flag indicates that this is a ground based duct, the scaled height is set to the larger of 0.1 and $Z = H/D$

where

H = target height

D = ground based duct height

If Z is greater than 0.8 then the height gain is

$$F_{Zr} = 1.55\ Z^{-5.57} - 10$$

otherwise,

$$F_{Zr} = 8.686\ \ln\ (\sin(Z\#))$$

If the duct is an evaporation duct, the scaled height is

$$Z = (Zfac)(H)$$

The evaporation duct height gain calculation follows:

$$F_{Zr} = C1\ Z^{C2} + C3\ Z^{C4} + C5 \qquad Del < 10.25$$

$$= C1\ \ln[\sin(C3\ Z^{3/2})] + C4 \qquad Del \geq 10.25 \text{ and } Z \leq Hlm$$

$$= C5\ Z^{C6} + C7 \qquad Del \geq 10.25 \text{ and } Z > Hlm$$

where

C1, C2, C3, C4, C5, C6, C7 and Hlm were computed in the

Diffraction Region Subroutine.

Control then returns to the Surface Trace Subfunction.

3.4.2.21.3 Outputs

Height gain in this diffraction zone for the target height.

3.4.2.22 Rayplot Subfunction

3.4.2.22.1 Inputs

a. Height offset at zero range (H_{off})

b. Height (H)

c. Range (R)

3.4.2.22.2 Processing

This subfunction is called by the Trapped, Negative Launch Angle, Ray Minimum, and Downgoing Subfunctions. The height in screen units is

$$H_s = H_{off} - \frac{3R^2}{50.968} + H$$

where

H_{off} = height offset

A vector is drawn to position (R, H_s) on the screen

Control is then returned to the calling subfunction.

3.4.2.22.3 Outputs

A vector on the screen in 4/3 earth coordinates.

3.4.2.23 Print Page Subfunction

3.4.2.23.1 Inputs

a. The Cover System Data Set (see 3.4.9)

b. The Environmental Data Set (see 3.4.7)

3.4.2.23.2 Processing

This subfunction is called by the Airborne, Envelope, and Surface Subfunctions. This subfunction is called to label and print out the plot. If the system is classified, its classification is printed at the top of the page. The plot label identifying the display as coverage diagram and the system name, the location, and time are printed next. The plot itself is sent to the display followed by the labels which include the free space range, the frequency, and the radar height. If IREPS is in Auto-Mode, the Auto-Mode Function (3.4.1) is invoked. Otherwise the Options Function (3.4.10) is called.

3.4.2.23.3 Outputs

Cover plot with labels.

3.4.2.24 Error Subfunction

3.4.2.24.1 Outputs

None.

3.4.2.24.2 Processing

This subfunction is referenced by any other subfunction to display a message to the operator indicating that an invalid or erroneous response has been made in response to a prompt. A mass storage device error also causes a reference to this subfunction.

In case of a mass storage device error, this subfunction causes a fatal error after informing the operator that a malfunction has occurred with the mass storage device. Any diagnostic information available is also displayed to the operator, then the processor is halted.

3.4.2.24.3 *Outputs*

Message displayed to operator.

3.4.3 Edit Function

This function allows the operator to revise data or amend library contents. The options provided for editing include:

a. Change an Environmental Data Set

b. Delete an Environmental Data Set from the library

c. Change a Cover System Data Set

d. Input a Cover System Data Set

e. Delete a Cover System Data Set from the library

f. List the the Auto-Mode command array

g. Input a command array for use by the Auto-Mode Function

h. Input a Loss System Data Set

i. Change a Loss System Data Set

j. Delete a Loss System Data Set from the library

k. End the Edit Function

The operator types in the appropriate command for the kind of editing to be provided to choose which of these above actions will be taken.

3.4.3.1 Edit Entry Subfunction

3.4.3.1.1 Inputs

None.

3.4.3.1.2 Processing

This subfunction is called by the Options Function. First the Set-Up Subfunction (3.4.3.33) is referenced followed by a display of operator options. The operator is prompted to make a selection. If the

"Back-Up", "End", or "Options" Command is entered, control is transferred to the Options Function (3.4.10). If an invalid entry is made, the Error Subfunction is referenced followed by reprompting the operator. Depending on the operator selection, control is transferred to the subfunction, as listed in Table 3.4.3-1

3.4.3.1.3 Outputs

a. Menu of selections

b. Operator prompts

c. Flag indicating if operator wants to input a Coverage or Loss System Data Set

d. Flag indicating if operator wants to edit a Coverage or Loss System Data Set

e. Flag indicating if operator wants to input or delete a Coverage System Data Set

f. Flag indicating if operator wants to input or delete a Loss System Data Set

Table 3.4.3-1

EDITING SUBFUNCTIONS

Subfunction	Purpose
Edit Environment	Change Environmental Data Set
Delete Environment	Eliminate an Environmental Data Set
Input System	Create a Cover or Loss System Data Set
Edit System	Edit a Cover or Loss System Data Set
Delete System	Delete a Cover or Loss System Data Set
Input Automatic Line	Create an Auto-Mode command array
List Automatic Line	Display an Auto-Mode command array

3.4.3.2 Edit Environment Subfunction

3.4.3.2.1 Inputs

None

3.4.3.2.2 Processing

This subfunction is called by the Edit Entry Subfunction. If the operator has entered the "Options" command, the Environmental Data Set is read from the mass storage device and control is transferred to the Options Function. Otherwise the List Environmental Data Sets Subfunction (3.4.3.12) is referenced. The operator is next prompted to select the number of the data set to be edited. If the operator enters the "Back-Up" or "End" command, control is transferred to the Edit Entry Subfunction. An invalid entry causes the Error Subfunction to be referenced followed by another prompt to the operator. A valid entry causes the selected Environmental Data Set to be read from the mass storage device. See 3.4.7 for the data set format.

If the value of the Change variable read from the Environmental Data Set is 1, the last item in the M units and N units arrays is set to zero, and the count of the items in these arrays is decremented by one. If the data set is protected, a flag is set.

If the data type is not WMO message or radiosonde, the following algorithm is executed.

Step 1. The height conversion factor is set. It is 1 if metres are to be used, or 0.3048 otherwise.

Step 2. All of the items in the height array are then converted to the proper units as follows

$$\text{Height (i)} = \frac{\text{Height (i) - Height Zero}}{\text{Height Conversion Factor}}$$

where

Height (i) = ith element of the height array

Height Zero = height offset from mean sea level

Step 3. Reference the Invert Subfunction. Terminate the algorithm.

Next the number, name, location, date, and time of the data set is displayed followed by the type of input:

a. Radiosonde
b. M units
c. N units
d. WMO message
e. Refractometer

The following steps are executed to print the remaining data items.

Step 1. The units for height (feet or metres) as specified by the operator and true wind speed in kts are then printed.

Step 2. If evaporation duct parameters are specified, the air and sea temperature and relative humidity used in computing δ are printed.

Step 3. If the type is WMO message, the code group for the height of 1000 mb is printed, then go to Step 6.

Step 4. If type is radiosonde, print the launch height above mean sea level. Otherwise print the offset from mean sea level.

Step 5. The station pressure at the launch height is printed for radiosonde data.

Step 6. If the protected data set flag is set, a message so stating is printed. Otherwise a "Not Protected" message is printed. End of print out.

The operator is then prompted to identify which type of data will be changed in the data set. If the operator enters the "Back-Up" command, control is transferred to the beginning of this subfunction. The "End" command transfers control to the End of Profile Data Edit Subfunction. An invalid entry references the Error Subfunction followed by reprompting the operator. A valid entry transfers control to one of the editing procedures below.

3.4.3.2.2.1 Location

The operator is prompted to enter the location (24 ASCII characters maximum). Entry of the "Back-Up" command transfers control to the start of this subfunction. The entry is stored in the Location variable. (The default is "Not Specified".) Control is transferred to the start of this subfunction.

3.4.3.2.2.2 Date/Time

The operator is prompted to enter the date and time (24 ASCII characters maximum). Entry of the "Back-Up" command transfers control to the start of this subfunction. The entry is stored in the Time variable. (The default is "Not Specified".) Control is transferred to the start of this subfunction.

3.4.3.2.2.3 Type

The type of data can only be changed between M units and N units (WMO message, radiosonde, and refractometer types cannot be changed). If the type is M units it is changed to N units, and if originally N units it is changed to M units. Control is transferred to the start of this subfunction in any case.

3.4.3.2.2.4 Height Units

If type is WMO message, height units cannot be changed because no height is specified. Otherwise the height conversion factor is changed to the opposite state and control is transferred to the start of this subfunction.

3.4.3.2.2.5 Wind Speed

The operator is prompted to enter the true wind speed in kts. The "Back-Up" command transfers control to the start of this subfunction. A value outside the limits of zero to 900 references the Error Subfunction and issues another prompt. A valid entry is stored in the Wind variable as

$$\text{Wind} = \frac{1.54432 \text{ Entry}}{3} \quad \text{m/s}$$

(The default is zero.) Control is transferred to the start of this subfunction.

3.4.3.2.2.6 Evaporation Duct Parameters

If evaporation duct parameters were entered, they are all zeroed. Control is then transferred to the start of this subfunction. If the parameters were not entered, the operator is prompted to enter the sea temperature, air temperature, and relative humidity. At each entry the "Back-Up" command transfers control to the start of this subfunction. An invalid entry references the Error Subfunction and reprompts the operator. Valid ranges are

Sea Temperature -50°C to 100°C

Air Temperature -50°C to 100°C

Relative Humidity 0 to 100 per cent

(The default value in each case is zero.) After all entries are made and stored in the corresponding variable, control is transferred to the start of this subfunction.

3.4.3.2.2.7 Sea and Air Temperature and Relative Humidity

These variables can also be set individually rather than in the serial fashion described in 3.4.3.2.2.6. The same procedure is followed.

3.4.3.2.2.8 Launch Height

A special procedure, described below, is used if the data type is WMO message. Otherwise the operator is prompted to enter the height offset or radiosonde launch height from mean sea level. If the "Back-Up" command is entered, control is transferred to the start of this subfunction. If an invalid entry is made, the Error Subfunction is referenced followed by another prompt. Valid limits are zero to 10^6. (Zero is the default.) The value is stored in the Height Zero variable and control returned to the start of this subfunction. If the type was WMO message, the operator is prompted to enter the height of the 1000 mb surface. If the "Back-Up" command is entered, control is transferred to the start of this subfunction. If the operator does not enter at least 5 ASCII characters the Error Subfunction is referenced followed by another prompt. If the entry is greater than 500, it is decremented by 500. If the entry (or decremented entry) is between -500 and 500 it is stored in the WMO Height variable and control is transferred to the start of this subfunction. Otherwise the Error Subfunction is referenced and another prompt issued.

3.4.3.2.2.9 Station Pressure

If data type is not radiosonde, a warning message to the operator stating that launch height is not specified with the current data type is printed followed by transfer of control to the start of this subfunction. If the data type is radiosonde, the operator is prompted to enter the pressure which is stored in the Pressure Zero variable, if a valid entry within the range of 0 to 1200 is made. (The default value is 1100.) If the "Back-Up" command is entered, control is transferred to the start of this subfunction. If an invalid entry is made, the Error Subfunction is referenced followed by a new prompt.

3.4.3.2.2.10 Protect Code

The protect code is changed to the opposite state and control is transferred to the start of this subfunction.

3.4.3.2.2.11 Profile Data or WMO Code Editing

The appropriate heading for the profile data is printed, as shown in Table 3.4.3-2, followed by a tabular array of the data.

TABLE 3.4.3-2

PROFILE PRINTOUT

Data Type	Heading			
Radiosonde	Level	Pressure	Temp(C)	Rel Hum (%)
M Units	Height			M Units
N Units	Height			N Units
WMO Message			Code	
Refractometer	Height			N Units

The operator is then prompted to select changing, deleting, inserting, or appending a level, code, or height. The operator can also terminate the editing with the "End" command. If the "Back-Up" command is entered control is transferred to the start of this subfunction. If an invalid entry is made, the Error Subfunction is referenced followed by another prompt. If a valid entry is made, control transfers to the appropriate procedure described below. (The default is to end the editing, which transfers control to the start of this subfunction.)

a. Change Data. The operator is prompted to enter the level to be changed. Entry of the "Back-Up" or "End" command transfers control to the beginning of the Profile Data or WMO Code Editing. If the level is not a valid one, the Error Subfunction is referenced followed by reprompting the operator. If the data type is radiosonde, control is transferred to the Edit Radiosonde Subfunction. If the data type is WMO message, control is transferred to the Edit WMO Subfunction. Otherwise control is transferred to Edit M-N Units Subfunction.

b. Append Data. If there are more than 28 levels already, a warning message is printed and the control is transferred to the beginning of the Profile Data or WMO Code Editing. If the data type is radiosonde, control is transferred to the Edit Radiosonde Subfunction. If the data type is WMO message, control is transferred to the Edit WMO Subfunction. Otherwise control is transferred to the Edit M-N Units Subfunction.

c. Insert Data. The operator is prompted to enter the level to be inserted. If the "End" or "Back-Up" command is entered, control is transferred to the beginning of the Profile Data or WMO Code Editing. If the insert level number is less than zero or exceeds the levels already existing, the Error Subfunction is referenced followed by another prompt. A valid entry is handled in the same manner as Append Data (3.4.3.2.2.11.b) except the level is set to the operator entry rather than one above the highest existing level number.

d. Delete Data. If only two levels currently exist, a warning message is displayed to the operator and control is transferred to the beginning of the Profile Data and WMO Code Editing. Otherwise the operator is next prompted to enter the number of the level to be deleted. If the "Back-Up" or "End" command is entered, control is transferred to the start of the Profile Data and WMO Code Editing. If an invalid level number is entered, the Error Subfunction is referenced followed by another prompt.

If the level to be deleted is not the top one (maximum height), the height, M units, N units, pressure, temperature, relative humidity, and WMO fields in the item above the level to be deleted are all moved down one level. This process is repeated for all the remaining levels in the array and the fields of the previous top level are zeroed. The count of the maximum number of levels in the array is decremented by one.

If the level to be deleted is the top level, all fields are zeroed and the maximum count is decremented by one.

3.4.3.2.3 Outputs

a. Operator prompts and warnings

b. Modified values in the Environmental Data Set

3.4.3.3 Edit M-N Units Subfunction

3.4.3.3.1 Inputs

Number of the level to be edited.

3.4.3.3.2 Processing

This subfunction is called by the Edit Environment Subfunction. The operator is prompted to enter the height for the level to be changed and the new M or N units value. If the entry is all blanks, the "Back-Up" command, or the "End" command, control is transferred to the start of the Profile Data and WMO Code Editing (3.4.3.2.2.11). An invalid number of entries causes a reference to the Error Subfunction followed by another operator prompt. A valid entry is converted to

$$N = M_e - (H_e + H_o)/6.371$$

or

$$M = N_e + (H_e + H_o)/6.371$$

where

M_e, N_e = operator entry of M or N units

H_e = height entry in metres

H_0 = height offset from mean sea level

If the height is not the lowest level and the height entry is less than or equal to the height of the next lower level, the Error Subfunction is referenced followed by another operator prompt. If the height entry exceeds the height of the next higher level and the operator is changing data, the Error Subfunction is referenced followed by another prompt. If the height entry is greater than or equal to the present level and the operator is inserting data, the Error Subfunction is referenced followed by another prompt. The same error procedure is followed if the height is less than zero or greater than 10^5 or if the M_e or N_e input is less than zero or greater than 2×10^4.

If the operator is not changing data, the maximum count of level is incremented. If the top level is not the one being edited, the height, M Unit, and N Unit values in the array are all moved up one level beginning with the level above the one specified by the operator. The height entry and M or N calculated above are then stored in the level specified by the operator. Control is transferred to the start of the Profile Data and WMO Code Editing (3.4.3.2.2.11).

For a data change or editing of the top level, the height entry and M or N calculated above, are stored at the level specified by the operator. Control is transferred to the start of the Profile Data and WMO Code Editing (3.4.3.2.2.11).

3.4.3.3.3 Outputs

a. Operator prompts

b. Edited height and M or N units in the array

3.4.3.4 Edit Radiosonde Subfunction

3.4.3.4.1 Inputs

a. Number of the level to be edited

b. Edit and change flags

3.4.3.4.2 Processing

This subfunction is called by the Edit Environment Subfunction. The operator is prompted to enter the pressure, temperature, and relative humidity for the selected level. If the operator enters blanks or the "Back-Up" or "End" command, control is transferred to the start of the Profile Data and WMO Code editing (3.4.3.2.2.11). An invalid number of entries causes the Error Subfunction to be referenced followed by another prompt.

A validity check is made, and any of the following errors cause the Error Subfunction to be referenced followed by another prompt.

a. This is not the first level and the pressure entry is greater than or equal to the level below.

b. The operator is not appending, or this is not the top level with the operator changing, and (1) the pressure entry is less than or equal to the pressure at the present level and the operator is inserting or (2) the pressure is less than or equal to the pressure at the next level above and the operator is changing.

c. The pressure entry is less than zero or greater than 1200.

d. The temperature entry is less than -50°C or greater than 100°C.

e. The relative humidity entry is less than zero or greater than 100.

If the operator is not changing the data and this is not the top level, the pressure, temperature, and relative humidity for all levels above the current one are moved up one level in the array. The pressure, temperature and relative humidity of the current level are set to the operator entered values and control is transferred to the start of the Profile Data and WMO Code Editing (3.4.3.2.2.11).

In case this is the top level or the operator is changing data, the entered values are stored at the current level and control is transferred to the start of the Profile Data and WMO Code Editing (3.4.3.2.2.11).

3.4.3.4.3 Outputs

a. Operator prompts

b. Edited values of radiosonde data

3.4.3.5 Edit WMO Subfunction

3.4.3.5.1 Inputs

Number of the level to be edited.

3.4.3.5.2 Processing

This subfunction is called by the Edit Environment Subfunction. The operator is prompted to enter the code from the selected level. Entry of blanks or the "Back-Up" or "End" commands transfers control to the start of the Profile Data and WMO Code Editing (3.4.3.2.2.11).

The operator must enter data in the following format:

$$\underbrace{\text{nn}}_{\text{Index}}\ \underbrace{\text{PPP}}_{\text{Pressure}}\quad \underbrace{\ \ }_{\text{blank}}\quad \underbrace{\text{TTT}}_{\text{Temperature}}\ \underbrace{\text{DD}}_{\text{Dew point depression}}$$

Any deviation causes the Error Subfunction to be referenced followed by another prompt.

If the operator is changing data or the current level is the top one, the entered values are stored in the WMO field at the designated level. Control is transferred to the start of the Profile Data and WMO Code Editing (3.4.3.2.2.11).

Otherwise the fields are moved up one level starting with the level above the current one. The entered values are then stored in the designated level. Control is then transferred to the start of the Profile Data and WMO Code Editing (3.4.3.2.2.11).

3.4.3.5.3 Outputs

a. Operator prompts

b. Edited WMO Data

3.4.3.6 End of Profile Data Edit Subfunction

3.4.3.6.1 Inputs

Type of data flag

3.4.3.6.2 Processing

This subfunction is called by the Edit Environment Subfunction. If the type of data is WMO Radiosonde Code message, the WMO Decode Subfunction (3.4.3.10) is referenced. If the type is radiosonde or WMO message, the Convert Subfunction (3.4.3.8) is then referenced.

Next for all data types, except radiosonde or WMO message, the array heights are corrected for height offset

$$H_i = (H_i)(Htfac) + H_O$$

where

H_i = ith item in the Height array

Htfac = height conversion factor

H_O = height offset from mean sea level

The Invert Subfunction (3.4.3.9) is referenced next. If the height of the top layer is zero, control is transferred to the Delta Subfunction (3.4.3.7). Otherwise the count of the number of layer is incremented and the height of the top layer set to zero. The M units and N units corresponding to that height are computed to be:

$$M\ \text{Units (top)} = N\ \text{Units (top)}$$

$$= M\ \text{Units (top -1)} - \frac{0.75\ H(\text{Top-1})}{6.371}$$

where

top = index for the top element in the array

M Units (top-1) = M units for the layer just below the top one

H (top-1) = height for the layer just below the top one

Then control is transferred to the Delta Subfunction.

3.4.3.6.3 Outputs

Arrays arranged in the proper formats and sequence

3.4.3.7 Delta Subfunction

3.4.3.7.1 Inputs

a. Air temperature in °C

b. Sea temperature in °C

c. True wind speed.

d. Relative humidity

3.4.3.7.2 Processing

This subfunction is called by the End of Profile Data Edit Subfunction. This subfunction calculates the evaporation duct height with the following algorithm.

Step 1. Set δ to zero. If evaporation duct parameters were not entered by the operator go to Step 14.

Step 2. Convert temperature to absolute

T_A = Air temperature + 273.2

T_S = Sea temperature + 273.2

Step 3. Convert wind speed to knots

U = 3 Wind/1.54432

where

Wind = true wind speed in m/s

Step 4. Compute the bulk Richardson's number

$$R_{ib} = \frac{2214(T_A - T_S)}{T_A U^2}$$

Step 5. If $R_{ib} > 1$ then set it to 1

$$e_s = 6.105 \exp\left(25.22 \frac{T_A - 273.2}{T_A} - 5.31 \ln \frac{T_A}{273.2}\right)$$

$$e_o = 6.105 \exp\left(25.22 \frac{T_S - 273.2}{T_S} - 5.31 \ln \frac{T_S}{273.2}\right)$$

$$e_e = \frac{e_s \, RH}{100}$$

where

RH = relative humidity

Step 6. Compute ΔN

$$\Delta N = \frac{77.6}{T_A}\left[1000 + \frac{4810}{T_A} e_e\right] - \frac{77.6}{T_S}\left[1000 + \frac{4810}{T_S} e_o\right]$$

Step 7. Compute Γ

$\Gamma = 0.05$	$R_{ib} \leq -3.75$
$\Gamma = 0.065 + 0.004\ R_{ib}$	$-3.75 < R_{ib} - 0.12$
$\Gamma = 0.109 + 0.367\ R_{ib}$	$-0.12 < R_{ib} \leq 0.14$
$\Gamma = 0.115 + 0.021\ R_{ib}$	$0.14 < R_{ib}$

Step 8. Compute $Z_{1/L'}$

$$\frac{Z_1}{L'} = \frac{R_{ib}}{10\Gamma}\text{, where } Z_1 = 6 \text{ metres}$$

Step 9. If $R_{ib} \geq 0$ go to Step 12.

Step 10. Compute Ψ

$\Psi = -4.5 \dfrac{Z_1}{L'}$	$\dfrac{Z_1}{L'} \geq -0.1$
$\Psi = 10^{1.02 \log\left(-\frac{Z_1}{L'}\right) + 0.69}$	$-0.01 > \dfrac{Z_1}{L'} \geq -0.026$
$\Psi = 10^{0.776 \log\left(-\frac{Z_1}{L'}\right) + 0.306}$	$-0.026 > \dfrac{Z_1}{L'} \geq -0.100$
$\Psi = 10^{0.630 \log\left(-\frac{Z_1}{L'}\right) + 0.16}$	$-0.100 > \dfrac{Z_1}{L'} \geq -1$
$\Psi = 10^{0.414 \log\left(-\frac{Z_1}{L'}\right) + 0.16}$	$-1 > \dfrac{Z_1}{L'} \geq -2.20$
$\Psi = 2$	$\dfrac{Z_1}{L'} < -2.2$

Step 11. Begin to compute δ

$$B = \ln \frac{6}{1.5 \times 10^{-4}} - \Psi$$

$$D = \left(\frac{-0.125B}{\Delta N}\right)^4 - 18\left(\frac{-0.125B}{\Delta N}\right)^3 \left(\frac{R_{ib}}{60\Gamma}\right)$$

If D > 0 - then set $\delta = D^{-0.25}$ and go to Step 14.

Step 12. If $\Delta N \geq 0$ go to Step 14.

Step 13. Continue computation of δ.

$$B = \ln \frac{6}{1.5 \times 10^{-4}} + 5.2 \frac{Z_1}{L'}$$

$$\delta = \frac{\Delta N}{-0.125B - 5.2\Delta N \dfrac{R_{ib}}{60}}$$

If $\delta \geq 0$ and $\dfrac{\delta R_{ib}}{60} \leq 1$ go to step 14.

$$\delta = \frac{6.2\Delta N + 3.9}{-0.125 \ln \left(\dfrac{6}{1.5 \times 10^{-4}}\right)}$$

Step 14. If $\delta > 40$ then set δ to 40

Step 15. Transfer control to the Store Data Subfunction (3.4.3.11).

3.4.3.7.3 Outputs

Evaporation duct height δ.

3.4.3.8 Convert Subfunction

3.4.3.8.1 Inputs

a. Temperature, relative humidity, and pressure arrays

b. Number of items in the arrays (NMAX)

c. Air temperature

3.4.3.8.2 Processing

This subfunction is called by the End of Profile Data Edit Subfunction. This subfunction converts the input array values to arrays of height and M or N units. Each value is calculated by the following algorithm.

Step 1. Set H_0 to height zero

Step 2. Set P_0 to pressure zero.

Step 3. Repeat Steps 4 through 11 for each set of data. The index runs from 1 to NMAX.

Step 4. Calculate absolute air temperature

$T_A = T(i) + 273.2$

where $T(i)$ = air temperature in ^{o}C for level i.

Step 5. Set $P_1 = P_i$

Step 6. Compute water vapor pressure in millibars

$$E_e = \frac{R_i \; 6.105 \exp \; 25.22\left[(T_A-273.2)/T_A - 5.31 \ln \frac{T_A}{273.2}\right]}{100}$$

where R_i is the relative humidity array item

$T^*_1 = T_A + 0.3794017\, T_A\, E_e/(P_1-E_e)$

Step 7. If this is the first iteration (that is, i = 1) set

$T_0{}^* = T_1{}^*$

Step 8. Compute height and store in array

$$H_i = H_o + 14.63\,(T_1^* + T_o^*)\ln(P_o/P_1)$$

Step 9. Compute M and N units and store in arrays

$$M_i = \frac{77.6\,(P_1 + 4810\,E_e/T_A)}{T_A} + \frac{H_i}{6.371}$$

$$N_i = M_i - \frac{H_i}{6.371}$$

Step 10. Set up variables for next iteration

$H_o = H_i$

$P_o = P_1$

$T_o^* = T_1^*$

Step 11. Go to Step 4.

Control is then returned to the calling subfunction.

3.4.3.8.3 Outputs

Arrays containing height, M units, and N units.

3.4.3.9 Invert Subfunction

3.4.3.9.1 Inputs

a. Height, M units, and N units arrays

b. Number of items in the arrays (NMAX)

3.4.3.9.2 Processing

This subfunction is called by the End of Profile Data Edit Subfunction. This subfunction inverts the order of the height, M units, and N units arrays to put heights in decreasing order. If no entry for a height of zero was made by the operator, an extrapolated value for M at height zero (at array item number NMAX) is computed by the following:

$$M_{NMAX} = M_{NMAX-1} - \frac{0.75\ H_{NMAX}}{6.371}$$

where

M_{NMAX-1} = next to last item in the inverted M units array

H_{NMAX} = last height value in the inverted array.

Then a corresponding N_{NMAX} is found

$$N_{NMAX} = M_{NMAX}$$

3.4.3.9.3 Outputs

Inverted height, M units and N units arrays. The Change flag is set to indicate whether or not extrapolated values were computed for the M and N values at a height of zero.

3.4.3.10 WMO Decode Subfunction

3.4.3.10.1 Inputs

WMO code group.

3.4.3.10.2 Processing

This subfunction is called by the End of Profile Data Edit Subfunction. The purpose of this subfunction is to decode pressure, temperature, and dew point depression values in the WMO radiosonde message format of Federal Meteorological Handbook No. 4.

The processing of each entry converts the WMO message code group to pressure, temperature, and relative humidity and stores the values in their respective arrays. The following algorithm is used.

Step 1. If the pressure <100 and the dew point depression code is not two slashes the pressure is incremented by 1000. If this is the first code group go to Step 3.

Step 2. If the previous pressure was less than or equal to 100, the current pressure value is divided by 10.

Step 3. If the temperature code (TTT) is an odd number, change the sign to negative.

Step 4. If the dew point depression code is two slashes, go to Step 6.

Step 5. Convert dew point depression code (DD) to relative humidity.

$$X = \frac{DD}{10} \qquad 50 \geq DD$$

$$X = DD-50 \qquad \text{otherwise}$$

Compute dew point temperature.

$$T_d = TTT-DD$$

Compute environmental vapor pressure

$$E_{EVIRON} = 6.1078 \left(10^{7.5T_d/(T_d + 237.3}\right)$$

Compute saturation vapor pressure

$$E_{SAT} = 6.1078 \left(10^{7.5TTT/(TTT + 237.3}\right)$$

$$\text{Relative humidity} = \frac{100\ E_{ENVIRON}}{E_{SAT}}$$

Go to Step 7.

Step 6. Relative humidity = 19

Step 7. If this is the first code group, set the environmental vapor pressure at the surface level (E_e) to $E_{ENVIRON}$.

Step 8. If relative humidity is less than 19, set it to 19. If this is the first code group go to Step 10.

Step 9. If the current pressure code group is greater than the previous one, display an error message, and display a message to the operator asking whether editing will continue or control is to return to the start. In the former case, the original data set is read from the mass storage device, and control is transferred to the Edit Environment Subfunction (3.4.3.2). In the latter case control is transferred to the Edit Environment Subfunction directly.

Step 10. Check values are within limits. For any values exceeding these limits, display an error message, and display a message to the operator asking whether editing will continue or control is to return to the start. In the former case, the original data set is read from the mass storage device, and control is transferred to the Edit Environment Subfunction. In the latter case control is transferred to the Edit Environment Subfunction directly.

Valid Limits

$0 < \text{pressure} < 1200$

$-80 < \text{temperature} < 100$

$0 < \text{relative humidity} < 100$

Step 11. Save the pressure, temperature, and relative humidity values in the next item of their respective arrays.

After all WMO message values are stored, the following system variables are computed:

P_o = Pressure (1)

T_A = Temperature (1) + 273.2

$$T^* = T_A + \frac{0.3794017 T_A E_e}{P_o - E_e}$$

where

P_o = Pressure zero

Pressure (1) = First item in the pressure array

T_A = Absolute temperature

Temperature (1) = First item in the temperature array

T^* = Virtual temperature

Height zero is set to

$$\text{Height zero} = Hl - 29.29T^* \ln \frac{P_o}{1000}$$

where Hl = radiosonde launch height.

Control is then transferred to the Edit Environment Subfunction.

3.4.3.10.3 Outputs

a. Pressure, temperature, and relative humidity array values

b. Radiosonde launch height

c. Pressure zero

d. Absolute temperature

e. Virtual temperature

f. Height zero

g. Data set type flag.

3.4.3.11 Store Data Subfunction

3.4.3.11.1 Inputs

Edited environmental data

3.4.3.11.2 Processing

This subfunction is called by the Delta Subfunction. A message is displayed asking the operator if data is to be re-stored. A "no" reply causes the original data set to be retrieved and control to be transferred to the Edit Environment Subfunction. The "Back-Up" command transfers control to the Edit Environment Subfunction. Any other response, except "yes", causes the Error Subfunction to be referenced and another prompt to be displayed. A "yes" reply causes the original environmental data on the mass storage device to be replaced with the edited version. The data set is protected, if the operator requested it. Control is then transferred to the Edit Environment Subfunction.

3.4.3.11.3 Outputs

a. Operator prompts

b. Edited data set stored on the mass storage device.

3.4.3.12 List Environmental Data Sets Subfunction

3.4.3.12.1 Inputs

None

3.4.3.12.2 Processing

This subfunction is called by the Edit Environment Subfunction. This subfunction prints a list of all existing Environmental Data Sets in the format shown in Figure 3.4.3-1.

Figure 3.4.3-1. Typical Environmental Data Set Listing

```
Existing Environmental Data Sets:

    0  NEW
    1  STANDARD               Protected
    2  SB DUCT 1K Ft          Protected
    3  EL DUCT 15 to 17 KFT   Protected
    4  17 JUN 0045Z
    5  EVAP DUCT
    6  FLIR TEST
    7  24 OCT 79
    8  25 OCT 79
```

3.4.3.12.3 Outputs

Existing Environmental Data Sets listing

3.4.3.13 Delete an Environment Subfunction

3.4.3.13.1 Inputs

None

3.4.3.13.2 Processing

This subfunction is called by the Edit Entry Subfunction. The List Environmental Data Set Subfunction is referenced to produce a listing. If there are no existing data sets, a message informing the operator of the situation is displayed, then control is transferred to the Input Function (3.4.7).

Otherwise the operator is prompted to enter the line number of the data set to be deleted. Entry of either the "Back-Up" or "End" commands transfers control to the Edit Entry Subfunction (3.4.3.1). An invalid entry causes a reference to the Error Subfunction followed by another prompt.

If the selected data set is protected, a message is displayed to the operator. In such a case the operator is asked to verify that the data set is to be deleted. Any reply except "yes" transfers control to the start of this subfunction. A "yes" answer causes the record containing the data set to be deleted, then control is transferred to the beginning of this subfunction.

3.4.3.13.3 Outputs

a. Operator prompts

b. Record containing the specified data set is deleted from the mass storage device.

3.4.3.14 Input System Subfunction

3.4.3.14.1 Inputs

None.

3.4.3.14.2 Processing

This subfunction is called by the Edit Entry Subfunction. The List System Subfunction (3.4.3.30) is referenced, and if no systems exist, a message is printed informing the operator of that fact. If 32 systems already exist, a message is displayed for the operator and control is transferred to the Edit Entry Subfunction.

Otherwise, the System Name Subfunction (3.4.3.16) is referenced. If the operator entered the "Back-Up" command, control is transferred to the Edit Entry Subfunction. If the "Back-Up" command was not entered, the following subfunctions are referenced in the sequence listed:

a. System Name

b. System Display Type

c. Platform Type

d. Antenna Height

e. Frequency

f. Free Space Range

g. Antenna Type

h. Vertical Beamwidth

i. Antenna Elevation Angle

j. Security Classification

k. Label

Upon return from each subfunction, if the operator entered the "Back-Up" command the preceding subfunction in the list is referenced. (For example when control returns from the Frequency Subfunction, the operator entry contains a "Back-Up" command. The Antenna Height Subfunction will be referenced next.) In this manner the operator can move up or down the list in the sequence given.

After the Label Subfunction (3.4.3.26) has been referenced, a message asks the operator if the system is to be stored. A "yes" reply transfers control to the Store System Subfunction (3.4.3.27). The Label Subfunction is then referenced again.

3.4.3.14.3 Outputs

a. Operator prompts

b. New system stored on the mass storage device.

3.4.3.15 Edit System Subfunction

3.4.3.15.1 Inputs

None.

3.4.3.15.2 Processing

This subfunction is called by the Edit Entry Subfunction. The List System Subfunction is referenced. If no system data is stored, a warning message is displayed and control is transferred to the Edit Entry Subfunction. Otherwise the operator is prompted to enter the number of the System Data Set to be edited. (The default value is 1.) Entry of the "Back-Up" command causes control to transfer to the Edit Entry Subfunction. An invalid entry causes a reference to the Error Subfunction followed by another prompt. A valid entry references the Read System Subfunction (3.4.3.28) then transfers control to the following algorithm.

Step 1. Depending on the display flag, the height and range values are obtained as listed in Table 3.4.3-3.

Table 3.4.3-3. System Height and Range Values

Option	Height	Units	Range	Units
A	50,000	ft	200	nm
B	25,000	ft	100	nm
C	10,000	ft	50	nm
D	20,000	m	400	km
E	10,000	m	200	km
F	5,000	m	100	km
G	User Specified at runtime			

Step 2. The name of the coverage or loss diagram is printed.

Step 3. The range and height of the display are printed. For cover systems height is also printed.

Step 4. Conversion factors are set up.

Factor	Type of Units Used on Display	
	English	Metric
Height Conversion	0.3048	1
Range Conversion	1.85	1

Step 5. The type of platform is printed (surface-based or airborne).

Step 6. For surface-based systems the antenna height is printed. For airborne systems the antenna height is not specified.

Step 7. The frequency and free space range are printed.

Step 8. The antenna type is printed. The selection includes:

a. Omnidirectional

b. Sin x/x

c. Height-finder

d. Cosecant-squared

Step 9. The vertical beamwidth and antenna elevation angle are printed for all types of antennas except omnidirection, for which they are not specified.

Step 10. The security classification is printed.

Step 11. The label is printed.

Step 12. The operator is prompted to identify the data item to be edited. Entry of the "Back-Up" command transfers control to the beginning of this subfunction. Entry of the "End" command causes the "re-store data" query to print-out. A "yes" reply causes the Store System Subfunction (3.4.3.27) to be referenced followed by a transfer of control to the Edit Entry Subfunction. Any other reply transfers control to the Edit Entry Subfunction directly. An invalid entry references the Error Subfunction followed by another prompt. A valid entry references the appropriate subfunction as listed in 3.4.3.14.2 a through k.

Step 13. Transfer control to the start of the selected subfunction.

3.4.3.15.3 Outputs

a. Operator prompts

b. Revised system stored on the mass storage device.

c. Updated entries in a Coverage or Loss System Data Set.

3.4.3.16 System Name Subfunction

3.4.3.16.1 Inputs

None.

3.4.3.16.2 Processing

This subfunction is called by the Input System Subfunction. The operator is prompted to enter the system name. The "Back-Up" command transfers control to Step 12 of the Edit System Subfunction. The default is "not specified". The name entry is printed out. Control returns to the calling subfunction.

3.4.3.16.3 Outputs

a. Operator prompt

b. System name message

3.4.3.17 System Display Type Subfunction

3.4.3.17.1 Inputs

None.

3.4.3.17.2 Processing

This subfunction is called by the Input System Subfunction. If the system being edited is a coverage system, the altitude and range choices in Table 3.4.3-3 are displayed. If the system is a loss system, the choices in Table 3.4.3-4 are displayed.

Table 3.4.3-4. Loss System Maximum Range Values

Option	Maximum Range	Units
A	200	nm
B	100	nm
C	50	nm
D	400	km
E	200	km
F	100	km
G	User Specified at runtime (5 to 1000 km)	

In either case, the operator is prompted to select an option. The default is option A. Entry of the "Back-Up" command transfers control to Step 12 of the Edit System Subfunction. An invalid entry causes a reference to the Error Subfunction followed by another prompt. A valid entry sets the display type flag, initializes height and range conversion factors, and displays the option selected by the operator. Control returns to the calling subfunction.

3.4.3.17.3 Outputs

a. Operator prompts

b. Height and range conversion factors

c. Display option flag

3.4.3.18 Platform Type Subfunction

3.4.3.18.1 Inputs

Input/edit flag

3.4.3.18.2 Processing

This subfunction is called by the Input System Subfunction. The operator is prompted to enter the type of platform (surface or airborne). The default is surface. A "Back-Up" command transfers control to Step 12 of the Edit System Subfunction. An invalid entry causes a reference to the Error Subfunction followed by another prompt. A valid entry prints the type of platform. If the operator is editing a coverage or loss system and the platform type is surface, control is transferred to Step 4 of the Antenna Height Subfunction (3.4.3.19). If the operator enters the "Back-Up" command at that point, control is transferred to the beginning of this subfunction. When control returns from the Antenna Height Subfunction, the platform type flag is set. If the platform type is airborne, antenna height is set to zero. Control returns to the calling subfunction.

3.4.3.18.3 Outputs

a. Operator prompts

b. Platform type flag

c. Antenna height

3.4.3.19 Antenna Height Subfunction

3.4.3.19.1 Inputs

a. Platform type flag

b. Input/edit flag

3.4.3.19.2 Processing

This subfunction is called by the Input System and Platform Type Subfunctions.

Step 1. If platform type is surface, go to Step 4.

Step 2. If the operation is in the input mode, terminate the algorithm.

Step 3. Display a warning message that no antenna height entry is permitted for airborne platforms. Terminate the algorithm.

Step 4. The operator is prompted to enter the antenna height. The default is zero. Entry of the "Back-Up" command transfers control to Step 12 of the Edit System Subfunction.

Step 5. Check for validity. The antenna height entry is valid if

$3 \leq \text{entry} \leq 250$ and units are ft
$1 \leq \text{entry} \leq 80$ and units are m

An invalid entry causes the Error Subfunction to be referenced followed by another prompt.

Step 6. The valid entry is stored and a message displays the value.

Control returns to the calling subfunction.

3.4.3.19.3 Outputs

a. Operator prompts

b. Antenna height (surface platforms only)

3.4.3.20 Frequency Subfunction

3.4.3.20.1 Inputs

None

3.4.3.20.2 Processing

This subfunction is called by the Input System Subfunction. The operator is prompted to enter the frequency in MHz. (The default value is 100 MHz.) A "Back-Up" entry transfers control to Step 12 of the Edit System Subfunction. A valid entry is within the range of 100 MHz and 20,000 MHz. An invalid entry prints out a message of these limits, followed by causing the Error Subfunction to be referenced, followed by another prompt. A valid entry is stored and the frequency is displayed to the operator. Control returns to the calling subfunction.

3.4.3.20.3 Outputs

a. Operator prompts

b. Frequency

3.4.3.21 Free Space Range Subfunction

3.4.3.21.1 Inputs

Loss edit flag.

3.4.3.21.2 Processing

This subfunction is called by the Input System Subfunction. The operator is prompted to enter the free space range. (The default is zero.) A "Back-Up" command transfers control to Step 12 of the Edit System Subfunction. If a loss system is being edited, any entry greater than or equal to zero is valid. Otherwise an entry between zero and 1000 is valid. The valid entry is stored and displayed. An invalid entry causes a reference to the Error Subfunction followed by another prompt. Control returns to the calling subfunction.

3.4.3.21.3 Outputs

a. Operator prompts

b. Free space range

3.4.3.22 Antenna Type Subfunction

3.4.3.22.1 Inputs

Input/edit flag

3.4.3.22.2 Processing

This subfunction is called by the Input System Subfunction. The operator is prompted to enter the choice of antenna type. (The default is ommidirectional.) Entry of the "Back-Up" command transfers control to Step 12 of the Edit System Subfunction. An invalid entry causes the Error Subfunction to be referenced followed by another prompt. The operator selection is then printed. If the operation is in the edit mode and the antenna type is not omnidirectional, control is transferred to step 2 of the Vertical Beamwidth Subfunction (3.4.3.23). Entry of the "Back-Up" command at that point transfers control to the beginning of this subfunction. If the operator is in the edit mode and the antenna type is not omnidirectional, control is transferred to Step 2 of the Antenna Elevation Angle Subfunction (3.4.3.24). Entry of the "Back-Up" command at that point transfers control to Step 2 of the Vertical Beamwidth Subfunction. The antenna type is saved. If the type is omnidirectional, the vertical beamwidth and antenna elevation angle are set to zero. Control returns to the calling subfunction.

3.4.3.22.3 Outputs

a. Operator prompts

b. Antenna type

c. Vertical beamwidth

d. Antenna elevation angle

3.4.3.23 Vertical Beamwidth Subfunction

3.4.3.23.1 Inputs

Antenna type

3.4.3.23.2 Processing

This subfunction is called by the Input System and Antenna Type Subfunctions.

Step 1. If the antenna type is omnidirectional, a warning message is displayed and a "Back-Up" command entry is simulated.

Step 2. The operator is prompted to enter the vertical beamwidth. (The default value is zero.)

Step 3. Entry of the "Back-Up" command terminates the algorithm. A valid entry is greater than or equal to zero and less than or equal to 90. An invalid entry causes a reference to the Error Subfunction followed by another prompt.

Step 4. The valid entry is stored and displayed to the operator. Control returns to the calling subfunction.

3.4.3.23.3 Outputs

a. Operator prompts

b. Vertical beamwidth

3.4.3.24 Antenna Elevation Angle Subfunction

3.4.3.24.1 Inputs

a. Antenna type

b. Platform type

3.4.3.24.2 Processing

This subfunction is called by the Input System and Antenna Type Subfunctions.

Step 1. If the antenna type is omnidirectional, a warning message is displayed and a "Back-Up" command entry is simulated.

Step 2. The operator is prompted to enter the elevation angle. (The default value is zero.)

Step 3. Entry of the "Back-Up" command terminates the algorithm. Valid entries are in the range.

$$0 \le \text{entry} \le 10 \quad \text{surface platforms}$$

or

$$-10 \le \text{entry} < 0 \quad \text{airborne platforms}$$

An invalid entry causes a display of the valid limits, a reference to the Error Subfunction, and another prompt.

Step 4. Valid entries are stored and displayed to the operator. Control returns to the calling subfunction.

3.4.3.24.3 Outputs

a. Operator prompts

b. Antenna elevation angle

3.4.3.25 Security Classification Subfunction

3.4.3.25.1 Inputs

None

3.4.3.25.2 Processing

This subfunction is called by the Input System Subfunction. The operator is prompted to enter the security classification. (The default is unclassified.) Entry of the "Back-Up" command transfers control to Step 12 of the Edit System Subfunction. An invalid entry causes the Error Subfunction to be referenced followed by another prompt. A valid entry is stored and displayed to the operator. Control returns to the calling subfunction.

3.4.3.25.3 Outputs

a. Operator prompts

b. Security classification flag

3.4.3.26 Label Subfunction

3.4.3.26.1 Inputs

None

3.4.3.26.2 Processing

This subfunction is called by the Input System Subfunction. If the operator is in the edit mode, the existing label is displayed with the prompt. Entry of the "Back-Up" command transfers control to Step 12 of the Edit System Subfunction. The new label is stored (maximum 160 ASCII characters) and displayed to the operator. Control returns to the calling subfunction.

3.4.3.26.3 Outputs

a. Operator prompts

b. Label

3.4.3.27 Store System Subfunction

3.4.3.27.1 Inputs

a. Input/edit flag

b. Loss flag

c. Cover flag

3.4.3.27.2 Processing

This subfunction is called by the Input System and Edit System Subfunctions.

Step 1. If the operator is in the edit mode, go to step 3.

Step 2. Find a space for the new record. Store the new loss or coverage system name.

Step 3. Store the system in the appropriate record.

Step 4. Transfer control to the Edit Entry Subfunction.

3.4.3.27.3 Outputs

New system on the mass storage device

3.4.3.28 Read System Subfunction

3.4.3.28.1 Inputs

a. Cover flag

b. Loss flag

c. System name

3.4.3.28.2 Processing

This subfunction is called by the Edit System Subfunction. Using the loss and cover flags, the record number of the desired system is located in the loss or cover directory. The system is retrieved from the mass storage device and the name is displayed to the operator. Control returns to the calling subfunction.

3.4.3.28.3 Outputs

A loss or cover system is retrieved

3.4.3.29 Delete System Subfunction

3.4.3.29.1 Inputs

None

3.4.3.29.2 Processing

This subfunction is called by the Edit Entry Subfunction. The List System Subfunction is referenced, and if there is no existing system a warning message is printed, followed by transfer of control to the Edit Entry Subfunction. If systems have been listed, the operator is prompted to enter the line number of the system to be deleted. (The default is the "End" command.) Entry of either the "Back-Up" or "End" command transfers control to the Edit Entry Subfunction. An invalid entry causes the Error Subfunction to be referenced followed by another prompt. The record index for the desired system is removed from the directory and control is transferred to the start of this subfunction.

3.4.3.29.3 Outputs

The selected system is deleted from the mass storage device.

3.4.3.30 List System Subfunction

3.4.3.30.1 Inputs

a. System index

b. Cover flag

c. Loss flag

3.4.3.30.2 Processing

This subfunction is called by the Delete System, Edit System, and Input System Subfunctions. The record numbers for the desired type of systems (coverage or loss) are located, then the 160 ASCII labels of all the specified loss or coverage systems are listed. Control returns to the calling subfunction.

3.4.3.30.3 Outputs

Listing of system labels

3.4.3.31 List Automatic Line Subfunction

3.4.3.31.1 Inputs

Command file array

3.4.3.31.2 Processing

This subfunction is called by the Edit Entry Subfunction. If the command file array (see Figure 3.4.1-1) contains a zero in the number of active rows index, a message that no automatic commands exist is printed, and control is transferred to the Edit Entry Subfunction. Otherwise the number of copies for the list products and summary products is displayed. Next the index numbers of the coverage diagrams and loss diagrams for each row entered in the command file array are printed. If the number in the first column is -1, a repeat of the display in the row above is to be produced. If no "Repeat" command was encountered, the system name and record number are displayed followed by the display type. For airborne platforms the transmitter/radar height is displayed. Regardless of the platform type, the receiver/target height are displayed. Control is transferred to the Edit Entry Subfunction.

3.4.3.31.3 Outputs

Listing of the command file array

3.4.3.32 Input Automatic Line Subfunction

3.4.3.32.1 Inputs

None

3.4.3.32.2 Processing

This subfunction is called by the Edit Entry Subfunction.

Step 1. The operator is prompted to enter the number of copies of the Environmental Data List to be produced. (The default value is one.) The valid range is 1 to 9. Entry of the "Back-Up" command transfers control to the Edit Entry Subfunction. An invalid entry causes the error subfunction to be referenced followed by another prompt. The valid entry is saved and the number displayed.

Step 2. Next the operator is prompted to enter the number of copies of the Summary to be produced. Entry of the "Back-Up" command transfers control to Step 1. The valid range is 1 to 9 copies. (The default value is 1.) An invalid entry causes the Error Subfunction to be referenced followed by another prompt. A valid entry is saved and displayed to the operator.

Step 3. The number of cover and loss displays is set to zero. The cover flag is set.

Step 4. The List System Subfunction is referenced.

Step 5. The altitude and range options of the coverage diagram or the range options of the loss diagram are listed.

Step 6. Zero the display type, transmitter/radar height, and the receiver/target height variables. If this is a Cover Display entry, increment the number of cover diagrams. If this is a Loss Display entry, increment the number of loss diagrams.

Step 7. The operator is prompted to select the number of the coverage or loss diagram choice.

Step 8. Entry of the "Back-Up" command transfers control to Step 18. Entry of the "End" command transfers control to Step 19. Entry of the "Repeat" command transfers control to Step 17.

Step 9. If the input is not within the valid range, the Error Subfunction is referenced followed by another prompt.

Step 10. The appropriate coverage or loss record is retrieved from the mass storage device.

Step 11. If the type of display is user requested (Type G), the options are printed out, and operator is prompted to enter the type of display. (The default value is Type A.) Entry of the "Back-Up" command transfers control to Step 7. An invalid entry references the Error Subfunction and issues another prompt. A valid entry causes the display type to be saved and printed out.

Step 12. The platform type is displayed.

Step 13. For airborne platforms, the operator is prompted to enter the transmitter/radar height. (The default value is zero.) Entry of the "Back-Up" command transfers control to Step 7. A valid entry is in the range.

$$0 \leq \text{entry} < 10^6 \text{ m}$$

An invalid entry causes the Error Subfunction to be referenced followed by another prompt. A valid entry is stored and displayed to the operator.

Step 14. If the type of diagram is coverage, go to Step 16.

Step 15. The operator is prompted to enter the receiver/target height. (The default value is zero.) Entry of the "Back-Up" command transfers control to Step 7. A valid entry is in the range

$$0 \leq \text{entry} < 10^6 \text{ m}$$

An invalid entry causes the Error Subfunction to be referenced followed by another prompt. A valid entry is saved and displayed to the operator.

Step 16. The number of list or summary products, type of display, transmitter/radar height, and receiver/target height are stored in columns 1 through 4 respectively of the current row of the command file array (Figure 3). Go to Step 7.

Step 17. The first column of the current row in the command file array is set to -1 to signify a repeat, and the other columns in that row are zeroed. Go to Step 7.

Step 18. If this is a cover diagram entry, decrement the number of cover displays by 2. If this is a loss display entry decrement the number of loss displays by 2.

Step 19. If the number of cover displays is less than zero go to Step 2. If this is not the first row, decrement the index for the command file and zero that row in the array. If the number of loss displays is less than zero, go to Step 3.

Step 20. If this is a cover diagram entry, decrement the number of cover displays. If this is a loss diagram entry decrement the number of loss displays and go to Step 22.

Step 21. Set the loss flag and clear the cover flag. Go to Step 4.

Step 22. Save the command line in the command file array. Transfer control to the Edit Entry Subfunction

3.4.3.32.3 Outputs

Values for the command file array

3.4.3.33 Set-Up Subfunction

3.4.3.33.1 Inputs

None

3.4.3.33.2 Processing

This subfunction is called by the Edit Entry Subfunction. The Set-Up Subfunction is used to initialize the default values of all variables and arrays. The lengths of character variables and dimensions for all arrays are established. All files are assigned symbolic names. Control returns to the calling subfunction.

3.4.3.33.3 Outputs

None

3.4.3.34 Error Subfunction

3.4.3.34.1 Inputs

None

3.4.3.34.2 Processing

This subfunction is referenced by any other subfunction to display a message to the operator indicating that an invalid or erroneous response has been made in response to a prompt. A mass storage device error also causes a reference to this subfunction.

In case of a mass storage device error, this subfunction causes a fatal error after informing the operator that a malfunction has occurred with the mass storage device. Any diagnostic information available is also displayed to the operator, then the processor is halted.

3.4.3.34.3 Outputs

Message displayed to operator

3.4.4 ESM Function

This function generates a table of U.S. and Soviet emitters by frequency and maximum intercept range for the selected type of ESM receiver. Figure 3.4.4-1 is an example of the ESM Table. The emitters listed in the figure are always used in the print out.

3.4.4.1 ESM Entry Subfunction

3.4.4.1.1 Inputs

Environmental Data Set

3.4.4.1.2 Processing

This subfunction is called by the Options Function. The Set-Up Subfunction is referenced, then the operator is prompted to enter the type of ESM Receiver to be used for the table generation. Receivers A through K may be selected, see Figure 3.4.4-2. (Receiver A is the default.) Entry of the "Back-Up" command transfers control to the Options Function. Entry of an invalid type causes the Error Subfunction to be referenced followed by another prompt. A valid entry then prompts the operator to choose U.S., Soviet, or both emitter classes. Entry of the "Back-Up" command transfers control to the receiver type prompt above. An invalid entry causes the Error Subfunction to be referenced followed by another prompt. A valid entry transfers control to the ESM Print Subfunction.

***** ESM RANGE TABLE *****

LOCATION:NOT SPECIFIED
TIME:STANDARD

ESM RECEIVER: WLR-1 SS

EMMITER CLASS: SOVIET

EMMITER	FREQ (MHz)	MAX INTERCEPT RANGE (nmi)
KNIFE REST A	150	24
KNIFE REST B	353	76
CROSS BIRD	478	100
SQUARE HEAD	701	101
HIGH POLE	879	77
FAN SONG E MG	1145	162
TOP TROUGH	1407	195
BIG NET	1528	63
TOP SAIL	1539	139
HIGH LUNE	1663	172
SCOOP PAIR	1960	14
HEAD NET	2194	178
SLIMNET	2254	54
LOW SIEVE	2489	182
BALL END	2513	186
HIGH SIEVE	2721	170
FRONT DOOR	2999	85
TRAP DOOR	3219	167
STRUT PAIR	3321	14
STRUT CURVE	3569	126
FAN SONG E MT	3646	2

EMMITER	FREQ (MHz)	MAX INTERCEPT RANGE (nmi)
HEADLIGHT	3823	56
MUFF COB	3855	183
POP GROUP	4153	130
BASS TILT	4189	185
DRUM TILT	4302	167
OWL SCREECH	4324	112
SQUARE TIE	4568	62
SNOOP TRAY	4687	21
PEEL GROUP	4960	47
HAWK SCREECH	5083	46
TOP BOW	5213	19
SNOOP PLATE	5494	31
DONETS	5761	145
DONETS-2	5931	90
POT HEAD	6167	10
LOW TROUGH	6414	142
SUN VISOR	6432	32
NEPTUNE	6447	180
DON KAY	6576	196
DON/DON-2	6871	156

EMMITER CLASS: AMERICAN

EMMITER	FREQ (MHz)	MAX INTERCEPT RANGE (nmi)
SPS 43A	150	24
SPS-29	211	166
SPS-37	283	146
SPS-37A	319	177
SPS-32	463	192
SPS-40	590	175
SPS-43	779	110
IFF INT	814	56
TACAN	1045	189
SPS-39	1194	132
SPS-42	1491	14
SPS-41	1703	172
SPS-52	1715	114
MK-26	1767	194
SPS-39A	1917	149
MK-35 MOD 0	2057	107
SPS-33	2248	53
SPS-30	2466	38
SPN-43	2707	153
SPN-6	2788	81
SPS-10	2967	66
SPG-49 ACQ	3151	164
SPG-51	3308	148
MK-37	3541	143
BPS-5,9,11-15	3779	96
MK-13	3817	129
MK-34	4032	1

EMMITER	FREQ (MHz)	MAX INTERCEPT RANGE (nmi)
SPG-53A	4295	114
MK-68	4505	111
SPG-34	4671	146
SPG-50	4828	179
SPQ-9A	5013	147
MK-25 MOD 3	5297	25
MK-35 MOD 2	5338	197
MK-56	5504	181
MK-25 MOD 2	5626	118
MK-87	5847	24
SPN-35	6048	8
SPS-46	6302	133
SPS-53	6437	164
CPR 1500	6563	160
CPR 2900	6618	136
LN 66	6841	68
RAYTHEON 2502	6932	68
RAYTHEON 2840	6968	100
RAYTHEON 1900	7134	7
DECCA 202	7411	58
DECCA 914	7478	173
HEL-H 16 9	7596	41
SPS-55	7707	147
SPN-12	7783	88
MK-115	7807	92
SPG-53B	7840	111
SPN-41	8054	27

Figure 3.4.4-1. Typical ESM Range Table

OPTION	ESM RECEIVER
A	WLR-1 CV
B	WLR-1 CG/DD
C	WLR-1 SS
D	WLR-8 CV
E	WLR-11 CV
F	WLR-11 CG
G	TAC MK 105
H	SLQ-17 CV
I	SLQ-29 CV
J	SLQ-32 V1
K	SLQ-32 V2/3

Figure 3.4.4-2. ESM RECEIVER OPTIONS

3.4.4.1.3 Outputs

a. Operator prompts

b. Receiver type flag

c. Emitter class flag

3.4.4.2 ESM Print Subfunction

3.4.4.2.1 Inputs

a. Receiver type flag

b. Emitter class flag

3.4.4.2.2 Processing

The classification, heading, location, and time are printed. Next the type of receiver is printed. If only U.S. or Soviet emitters were selected, only one table is printed. Otherwise the Soviet followed by the U.S. table are printed. Data is found by table look-up by retrieval from the mass storage device. If a surface-based duct is indicated by the Environmental Data Set, the height of this duct is determined. The ESM ranges to be used in the tables are in this case those associated with the duct height of 150, 225, 300, 375, or 450 metres (whichever is closest to the actual duct height). If a surface-based duct does not exist, then the ESM ranges associated with the closest even numbered evaporation duct height in metres (in the interval 0 to 40 metres) are used. The classification is then printed at the bottom of the page. Control is next transferred to the Options Function (3.4.10).

3.4.4.2.3 Outputs

ESM range tables

3.4.4.3 Set-Up Subfunction

3.4.4.3.1 Inputs

None

3.4.4.3.2 Processing

This subfunction is called by the ESM Entry Subfunction. The Set-Up Subfunction is used to initialize the default values of all variables and arrays. The lengths of character variables and dimensions for all arrays are established. All files are assigned symbolic names. Control is returned to the calling subfunction.

3.4.4.3.3 Outputs

None

3.4.4.4 Error Subfunction

3.4.4.4.1 Inputs

None

3.4.4.4.2 Processing

This subfunction is referenced by any other subfunction to display a message to the operator indicating that an invalid or erroneous response has been made in response to a prompt. A mass storage device error also causes a reference to this subfunction.

In case of a mass storage device error, this subfunction causes a fatal error after informing the operator that a malfunction has occurred with the mass storage device. Any diagnostic information available is also displayed to the operator, then the processor is halted.

3.4.4.4.3 Outputs

Message displayed to operator

3.4.5 Historical Function

This function generates a report on historical propagation conditions for any location. The location is based on ocean areas as shown in Figure 3.4.5-1. The report format is shown in Figure 3.4.5-2. After the report is printed, the operator can use these data to fill the Height and M and N Unit arrays of the Environmental Data Set as an alternative to providing the data manually through the Input Function (see 3.4.7).

3.4.5.1 Area Selection Subfunction

3.4.5.1.1 Inputs

None

3.4.5.1.2 Processing

This subfunction is called by the Inputs Function. The Set-up Subfunction is referenced, then the operator is queried as to whether the map (Figure 3.4.5-1) should be displayed or not. (The default is "no".) Any entry except "yes" transfers control to the Historical Library Subfunction. A "yes" reply causes the Plot Map Subfunction to be referenced. The operator is then asked if a hard copy is required. A "yes" reply prints the map. In any case, control is then transferred to the Historical Library Subfunction.

3.4.5.1.3 Outputs

a. Operator prompts

b. Map plot

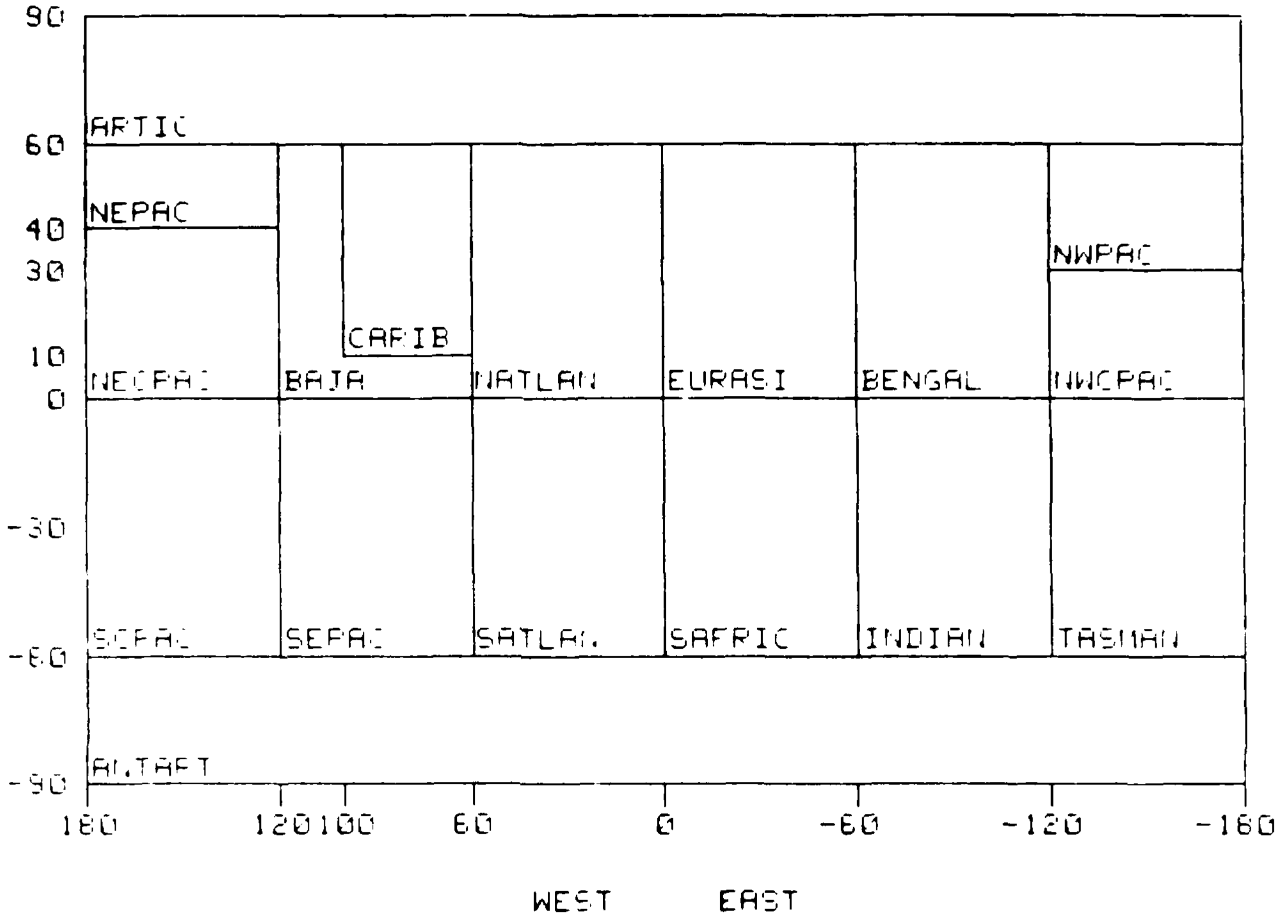


Figure 3.4.5-1. Ocean Areas

HISTORICAL PROPAGATION CONDITIONS SUMMARY

Specified Location:
Radiosonde Source: NM from location
Radiosonde Station Height: Feet
Surface OBS Source: NM from location

PERCENT OCCURRENCE OF ENHANCED SURFACE-TO-SURFACE RADAR/ESM/COM RANGES:

FREQUENCY BAND	YEARLY day nit d&n	WINTER day nit d&n	SPRING day nit d&n	SUMMER day nit d&n	AUTUMN day nit d&n
1 GHz to 1 GHz					
1 GHz to 3 GHz					
3 GHz to 6 GHz					
6 GHz to 10 GHz					
above 10 GHz					

SURFACE BASED DUCT SUMMARY:

PARAMETER	YEARLY day nit d&n	WINTER day nit d&n	SPRING day nit d&n	SUMMER day nit d&n	AUTUMN day nit d&n
Percent occurrence					
AVG thickness Kft					
AVG trap freq GHz					
AVG lyr grad N/Kft					

ELEVATED DUCT SUMMARY:

PARAMETER	YEARLY day nit d&n	WINTER day nit d&n	SPRING day nit d&n	SUMMER day nit d&n	AUTUMN day nit d&n
Percent occurrence					
AVG top ht Kft					
AVG thickness Kft					
AVG trap freq GHz					
AVG lyr grad N/Kft					
AVG lyr base Kft					

EVAPORATION DUCT HISTOGRAM IN PERCENT OCCURRENCE:

PERCENT OCCURRENCE	YEARLY day nit d&n	WINTER day nit d&n	SPRING day nit d&n	SUMMER day nit d&n	AUTUMN day nit d&n
0 to 10 Feet					
10 to 20 Feet					
20 to 30 Feet					
30 to 40 Feet					
40 to 50 Feet					
50 to 60 Feet					
60 to 70 Feet					
70 to 80 Feet					
80 to 90 Feet					
90 to 100 Feet					
above 100 Feet					
Mean height Feet					

GENERAL METEOROLOGY SUMMARY:

PARAMETER	YEARLY day nit d&n	WINTER dat nit d&n	SPRING day nit d&n	SUMMER day nit d&n	AUTUMN day nit d&n
% occur EL&SB dcts					
%occur 2 + EL dcts					
AVG station N					
AVG station N/Kft					
AVG sfc wind Kts					

Figure 3.4.5-2. Historical Condition Report

3.4.5.2 Historical Library Subfunction

3.4.5.2.1 Inputs

Historical Data Set

3.4.5.2.2 Processing

This subfunction is called by the Area Selection Subfunction. The operator is prompted to enter the latitude of the location in degrees. Minutes are optional. (The default value is 0^{o} N.) A negative entry is considered to be south latitude. Entry of the "Back-Up" command transfers control to the beginning of the subfunction, and another prompt is printed. Entry of a value less than -90 or greater than 90 causes the Error Subfunction to be referenced followed by another prompt. A valid entry is stored and displayed to the operator.

A prompt to enter longitude is then displayed. (The default value is 0^{o} W.) A negative entry is considered to be east longitude. Entry of the "Back-Up" command transfers control to the latitude entry above. Entry of a value less than -180 or greater than 180 causes the Error Subfunction to be referenced followed by another prompt. A valid entry is stored and displayed to the operator.

The operator is next prompted to enter the season. (The default is winter.) Entry of the "Back-Up" command transfers control to the longitude entry above. Valid entries are:

Season

Winter

Spring

Summer

Autumn

All

An invalid entry causes the Error Subfunction to be referenced followed by another prompt. A valid entry is stored and displayed to the operator.

A prompt then asks the operator to enter time of day. (The default is daytime.) Entry of the "Back-Up" command transfers control to the season entry above. Valid entries are: day, night, or all. An invalid entry causes the Error Subfunction to be referenced followed by another prompt. A valid entry is stored and displayed to the operator.

A determination is then made of which ocean area the selected latitude and longitude is located in. The ocean areas are shown in Figure 3.4.5-1. Table 3.4.5-1 lists the latitude and longitude limits for each area. Control is then transferred to the Station Subfunction.

3.4.5.2.3 Outputs

a. Operator prompts

b. Latitude and longitude

c. Season

d. Time of day

TABLE 3.4.5-1 OCEAN AREA BOUNDARIES

NAME	LATITUDE RANGE		LONGITUDE RANGE	
	Minimum	Maximum	Minimum	Maximum
ANTART	-90	-60	-180	180
ARTIC	60	90	-180	180
CARIB	10	60	60	100
BENGAL	0	60	-120	-60
BAJA	0	60	60	120
EURASI	0	60	-60	0
INDIAN	-60	0	-120	-60
NATLAN	0	60	0	60
NECPAC	40	60	120	180
NEPAC	40	60	120	180
NWCPAC	0	30	-180	-120
NWPAC	30	60	-180	-120
SAFRIC	-60	0	-60	0
SATLAN	-60	0	0	60
SCPAC	-60	0	120	180
SEPAC	-60	0	60	120
TASMAN	-60	0	-180	-120

3.4.5.3 Plot Map Subfunction

3.4.5.3.1 Inputs

Ocean Area Boundaries (Table 3.4.5-1)

3.4.5.3.2 Processing

This subfunction is called by the Area Selection Subfunction. Using the data from the input table, the map as shown in Figure 3.4.5-1 is plotted. Control is returned to the calling subfunction.

3.4.5.3.3 Outputs

Map Plot

3.4.5.4 Error Subfunction

3.4.5.4.1 Inputs

None

3.4.5.4.2 Processing

This subfunction is referenced by any other subfunction to display a message to the operator indicating that an invalid or erroneous response has been made in response to a prompt. A mass storage device error also causes a reference to this subfunction.

In case of a mass storage device error, this subfunction causes a fatal error after informing the operator that a malfunction has occurred with the mass storage device. Any diagnostic information available is also displayed to the operator, then the processor is halted.

3.4.5.4.3 Outputs

Message displayed to operator.

3.4.5.5 Set-Up Subfunction

3.4.5.5.1 Inputs

None

3.4.5.5.2 Processing

This subfunction is called by the Area Selection Subfunction. The Set-Up Subfunction is used to initialize the default values of all variables and arrays. The lengths of character variables and dimensions for all arrays are established. All files are assigned symbolic names. Control is returned to the calling subfunction.

3.4.5.5.3 Outputs

None

3.4.5.6 Station Subfunction

3.4.5.6.1 Inputs

a. Latitude and longitude entered by operator.

b. Ocean area containing the operator entered position.

3.4.5.6.2 Processing

This subfunction is called by the Historical Library Subfunction. This subfunction finds the radiosonde station within the selected ocean area closest to the operator entry. The closest surface observation station to the entry (regardless of ocean area) is also located. In both cases great circle navigation algorithms and the Historical Data Set (Table 3.5.1-3) are used. The following algorithm, implementing the cosine law of spherical geometry, finds the distance between the two points: From Figure 3.4.5-3

$$\cos(DIST) = \cos(S1)\cos(S2) + \sin(S1)\sin(S2)\sin\$$$

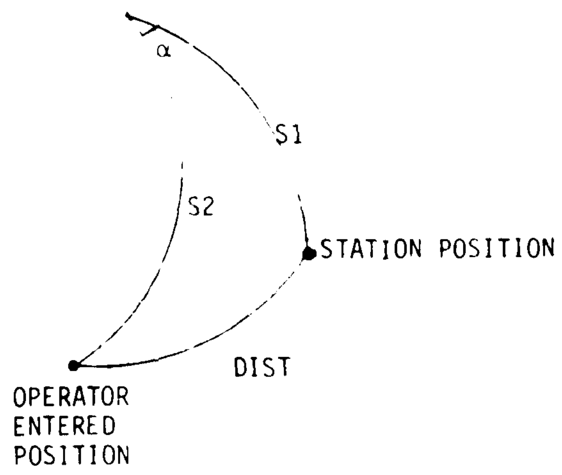


Figure 3.4.5-3. Cosine Law

Begin search for closest radiosonde observation station.

Step 1. $i=1$.

MIN DIST = 99999.

Step 2. $S1 = 90 - \text{Latitude}$

where

Latitude = operator entry

Step 3. Is the radiosonde observation station as indexed by i in the correct ocean area? if not go to Step 7.

Step 4. $S2 = 90 - \text{Lat}(i)$.

$\alpha = \text{Longitude} - \text{Lon}(i)$.

where

Longitude = operator entry

Lat(i), Lon(i) = station coordinates from Historical Data Set.

If $\alpha > 180$, set $\alpha = 360 - \alpha$.

Step 5. $DIST = \cos^{-1}[\cos(S1)\cos(S2) + \sin(S1)\sin(S2)\cos\alpha]$

Step 6. If DIST<MIN DIST, set MIN DIST = DIST and save the value of i.

Step 7. Have all radiosonde observation stations been checked? If not increment i and go to Step 3.

Begin search for the closest surface observation station.

Step 1. $i=1$.

MIN DIST = 99999.

Step 2. $S1 = 90 - \text{Latitude}$.

Step 3. $S2 = 90 - Lat(i)$.

$\alpha = Longitude - Lon(i)$.

If $\alpha > 180$, set $\alpha = 360 - \alpha$

Step 4. $DIST = \cos^{-1}[\cos(S1)\cos(S2) + \sin(S1)\sin(S2)\cos\alpha]$

Step 5. If DIST<MIN DIST, set MIN DIST = DIST and save the value of i.

Step 6. Have all surface observation stations been checked? If not increment i and go to Step 3. Otherwise transfer control to the Report Generation Subfunction.

3.4.5.6.3 Outputs

a. Index of the closest radiosonde station in the selected ocean area.

b. Index of the closest surface observation station.

3.4.5.7 Report Generation Subfunction

3.4.5.7.1 Inputs

a. Index of radiosonde station

b. Index of surface observation station

3.4.5.7.2 Processing

This subfunction is called by the Station Subfunction. This subfunction produces the Historical Propagation Conditions Summary of Figure 3.4.5-?. Using the input indices, the appropriate records are read from the Historical Data Set from the mass storage device. After the report heading is printed, the latitude and longitude of the location entered by the operator are printed. Next the identification, position, and distance of the radiosonde station from the entered position are printed. The radiosonde station height in feet follows. Similarly the identification, position, and distance of the surface observation station are printed.

In the tables which follow, annual, seasonal, day, night, and combined day and night values are printed. In all cases the annual and combined day and night values are computed averages:

$$\text{Annual} = \frac{\text{winter} + \text{spring} + \text{summer} + \text{autumn}}{4}$$

$$\text{Combined day and night} = \frac{\text{day} + \text{night}}{2}$$

The season category corresponds to months as follows:

	North Latitude	South Latitude
Winter	January February March	July August September
Spring	April May June	October November December
Summer	July August September	January February March
Autumn	October November December	April May June

3.4.5.7.2.1 Percent Occurrence of Enhanced Surface-to-Surface Radar/ESM/Comm Ranges

This table is computed using the following inputs from the Historical Data Set.

a. Median trapping frequency for surface ducts by season (F_{SB})

b. Percent occurrence of surface ducts by season, day, and night (P_{SB})

c. Percent occurrence of evaporation ducts by season, day, night, and height (P_{EV})

From the median trapping frequency, F_{SB}, an assumed occurrence histogram, as shown in Figure 3.4.5-4, is constructed. The area under the curve from 1 to log F_{SB} comprises 50 percent of the cumulative number of occurrences. This form of the distribution is assumed for all geographical areas, seasons, and times.

Using the histogram, the percentage occurrence, from surface base ducting effects, for the following frequency bands is found. (A band is defined as a range from a lower frequency, fl, to higher frequency, fh.)

a. 0.1 to 1 GHz

b. 1 to 3 GHz

c. 3 to 6 GHz

d. 6 to 10 GHz

e. Above 10 GHz

The percent occurrence for frequencies less than a given frequency, fi, is found by the following expressions:

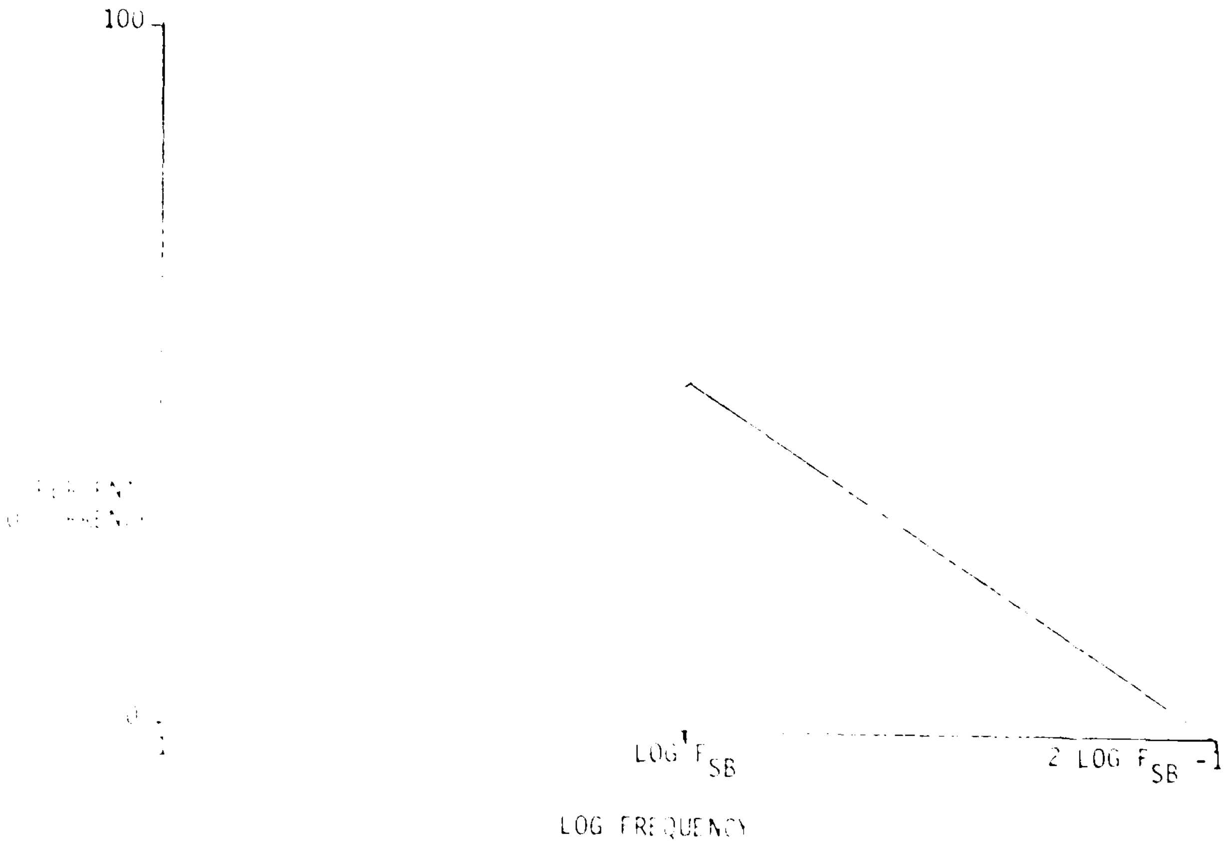


Figure 3.4.5-4. Percent Occurrence Histogram

$Pi = 0$ if $\log fi < 1$

$$Pi = 50 \left[\frac{\log fi - 1}{\log F_{SB} - 1}\right]^2 \qquad 1 \le \log fi \le \log F_{SB}$$

$$Pi = 100 - 50 \left[\frac{2 \log F_{SB} - \log fi - 1}{\log F_{SB} - 1}\right]^2 \qquad \log F_{SB} < \log fi \le 2 \log F_{SB} - 1$$

$Pi = 100$ $\log fi > 2 \log F_{SB} - 1$

For each of the frequency bands listed above, the percent occurrence of frequencies in that band is found by

$$Plh = Ph - Pl$$

where

Ph = Pi of the higher frequency of the band (for example $fh = 1$ GHz for band a above)

Pl = Pi of the lower frequency of the band (for example $fl = 0.1$ GHz for band a above)

Plh is then scaled by the percent occurrence of a surface based duct by

$$Sa = \frac{Plha\ P_{SB}}{100}$$

$$Sb = \frac{Plhb\ P_{SB}}{100}$$

$$Sc = \frac{Plhc\ P_{SB}}{100}$$

$$Sd = \frac{Plhd\ P_{SB}}{100}$$

$$Se = \frac{Plhe\ P_{SB}}{100}$$

where

Plha, Plhb, Plhd, Plhe = Plh for the frequency bands a through e respectively.

Hence, Sa through Se are the scaled percent occurrence of frequencies caused by surface based ducting in the band fl to fh for each frequency.

Using the values of the evaporation duct histogram, the percent occurrence for the frequency band occurrence caused by evaporative ducting effects is found.

$Ea = PEV\ (> 100)$

$Eb = PEV\ (80,90) + PEV\ (90,100)$

$Ec = PEV\ (60,70) + PEV\ (70,80)$

$Ed = PEV\ (20,30) + PEV\ (30, 40) + PEV\ (40,50) + PEV\ (50,60)$

$Ee = PEV\ (0,10) + PEV\ (10,20)$

where

PEV (X,Y) = Percent occurrence of evaporation ducts in the range X to Y ft.

Ea through Ee = percent occurrence due to evaporative ducting effects for the frequency bands a through e above respectively.

The percent occurrence of enhanced surface-to-surface Radar/ESM/Comm Ranges by frequency is computed by.

$Pa = Ea + Sa$

$Pb = Eb + Sb$

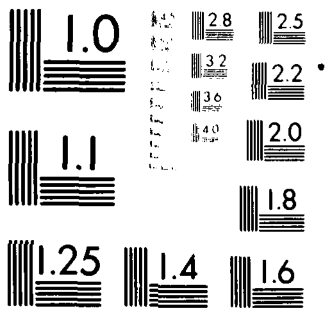
$Pc = Ec + Sc$

$Pd = Ed + Sd$

$Pe = Ee + Se$

AD-A092 297 MEGATEK CORP SAN DIEGO CA F/G 20/14
INTEGRATED REFRACTIVE EFFECTS PREDICTION SYSTEM (IREPS): PROGRA--ETC(U)
JUL 80 H V HITNEY, E W PASAHOW, M E O'BRIAN N00123-78-C-0043
UNCLASSIFIED R2018-059-IF-2 NOSC-TD-365 NL

3 of 5
AD
A092297



MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS 1963-A

The procedure is carried out for each season during the day and night. (Because F_{SB} is not tabulated separately by day and night, the same value is used in both cases for each season.)

3.4.5.7.2.2 Surface Based Duct Summary

Except for the last line, this summary table is printed using fields of the radiosonde station record.

The entries of percent occurrence correspond directly to the percent occurrence of surface based ducts by season, day, and night fields.

The average thickness in Kft corresponds to the median thickness of the surface duct field by season divided by 304.8 to convert to a scaling of thousands of feet. Because the data is not differentiated by day or night, only the day and night column (d&n) is printed.

The average trapping frequency is the median trapping frequency for surface ducts by season converted to GHz by dividing by 1000. Only the day and night (d&n) column is printed.

The average layer gradient is computed using the following inputs:

a. Median thickness for surface duct by season (H_{TSB})

b. Median inflection point for surface ducts by season (H_{ISB})

c. Median M unit deficit for surface based ducts by season (MD_{SB}).

The thickness of the layer is

$$Tl = H_{TSB} - H_{ISB} \quad m$$

The layer M unit gradient is

$$MG1 = \frac{MD_{SB}}{T1} \qquad \frac{\text{M units}}{\text{m}}$$

converting to N units per thousand feet

$$N_T = 304.8 \left(MG1 - \frac{1}{6.371}\right)$$

The values are printed only for the day and night (d&n) column.

3.4.5.7.2.3 Elevated Duct Summary

The percent occurrence row is found directly from the percent occurrence fields of the station radiosonde record by season, day, and night.

The average top height uses the tabulated values of the following fields:

a. Median height of elevated duct inflection point by season (H_{IEL})

b. Median thickness of elevated duct by season (H_{TEL})

c. Median M units deficit for elevated ducts by season (M_{DEL})

d. Median M unit gradient below elevated duct inflection point (M_{GEL})

e. Station height (S_{ELEV})

The value to be printed is found by

$$Toph = S_{ELEV} + H_{IEL} + H_{TEL} - 10^3 \frac{M_{DEL}}{M_{GEL}}$$

Convert to thousands of feet by dividing Toph by 304.8. Only the day and night (d&n) column is printed.

The average thickness corresponds to the seasonal values of median thickness of elevated ducts divided by 304.8 to convert to thousands of feet. Only the day and night (d&n) column is printed.

The average layer gradient is found by first computing the thickness of the layer

$$T1 = H_{TEL} - 1000 \frac{M_{DEL}}{M_{GEL}}$$

The layer M unit gradient is

$$MG1 = \frac{M_{DEL}}{T1} \quad \frac{\text{M units}}{\text{m}}$$

converted to *N units per thousand feet*

$$N_T = 304.8(MG1 - \frac{1}{6.371})$$

Only the day and night column (d&n) is printed.

The average layer base height in thousands of feet is found by

$$LB = \frac{S_{ELEV} + H_{IEL}}{304.8}$$

Only the day and night (d&n) column is printed.

3.4.5.7.2.4 Evaporation Duct Histogram

The evaporation duct histogram is printed by simple table look-up from the surface observation station record for the percent occurrence in 10 ft increments. The mean height is found in the fields for mean duct height by season and day or night.

3.4.5.7.2.5 General Meteorology Summary

The percent occurrence of elevated and surface based ducts is found in the probability of surface duct and elevated duct field by season. Only the day and night (d&n) column is printed.

The percent occurrence of two or more elevated ducts is found in the probability of more than one elevated duct field by season. Only the day and night (d&n) column is printed.

The average station N is found by

$$N = 0.3048\ (MG_{1000} - \frac{1000}{6.371})$$

where

MG_{1000} = Median M unit gradient from surface to 1000 m by season.

Only the day and night (d&n) column is printed.

The surface wind in knots is found in the mean wind speed by season, day, and night fields.

Control is then transferred to the Profile Generation Subfunction.

3.4.5.7.3 Outputs

Historical propagation conditions summary

3.4.5.8 Profile Generation Subfunction

3.4.5.8.1 Inputs

a. Historical Data Set

b. Season

c. Time of day

3.4.5.8.2 Processing

This subfunction is called by the Report Generation Subfunction. This subfunction determines the evaporation duct height δ and fills the height, M Units, and N Units arrays of the Environmental Data Set from data in the Historical Data Set. The operator is prompted to enter the type of profile desired. The valid entries are: standard, surface based duct only, elevated duct only, and combined ducts. Entry of the "Back-Up" command transfers control to the Report Generation Subfunction. An invalid entry causes the Error Subfunction to be referenced followed by another prompt. A valid entry causes the appropriate processing for the profile selected for the season and time of day to be completed. The value of δ is set to the mean duct height field corresponding to season and time of day. Control is then transferred to the Inputs Function.

3.4.5.8.2.1 Standard Profile

The standard profile uses these values and fields of the station radiosonde record.

a. Station height (S_{ELEV})

b. Median Surface N units (N_S)

c. Median M unit gradient from station to 1000 m (MG_{1000})

Figure 3.4.5-5 illustrates the parameters for this profile. The arrays

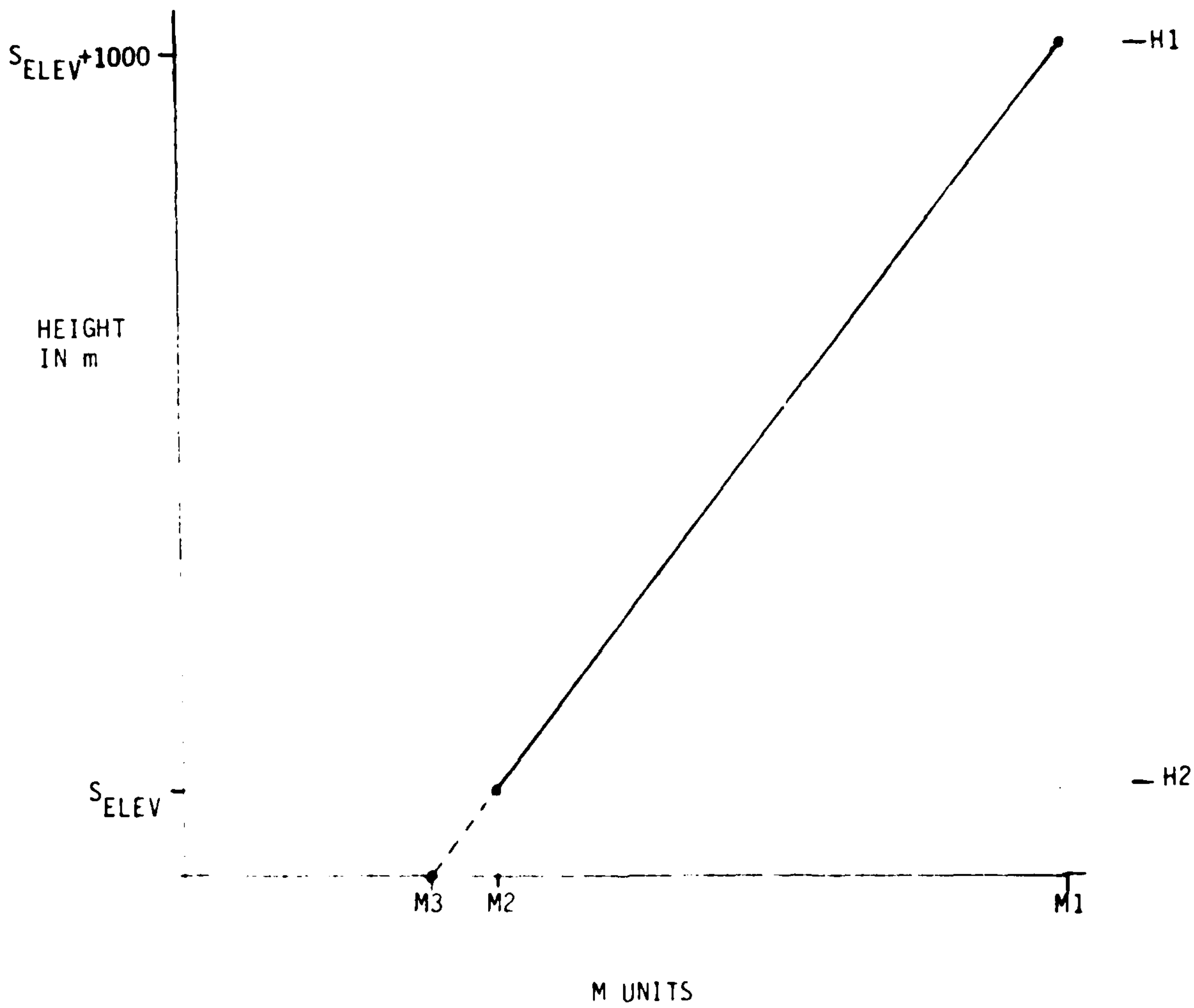


Figure 3.4.5-5. Standard Profile

will each contain three items.

$$M2 = N_S = \frac{S_{ELEV}}{6.371}$$

$$M1 = M2 + MG_{1000}$$

$$M3 = M2 - 0.11772\ H2$$

$$H2 = S_{ELEV}$$

$$H1 = H2 + 1000$$

$$H3 = 0$$

$$Ni = Mi - \frac{Hi}{6.371} \qquad i=1,2,3$$

where

Mi = M Units array item number i

Hi = Height array item number i

Ni = N Units array item number i

3.4.5.8.2.2 Surface Based Duct Only

This profile computation uses the following additional fields:

a. Median inflection point above station for surface ducts (H_{ISB})

b. Median thickness for surface ducts (H_{TSB})

c. Median M units gradient station to inflection point for surface ducts (MG_{SB})

d. Median M Units deficit for surface based ducts (MD_{SB})

Figure 3.4.5-6 shows the important values in these computations. Five items are stored in each array.

$$M2 = N_S + \frac{S_{ELEV}}{6.371}$$

$$M3 = M2 + \frac{MG_{SB}\ H_{ISB}}{1000}$$

$$M4 = M3 - MD_{SB}$$

$$M1 = M4 + MG_{1000}$$

$$M5 = M4 - 0.11772\ H4$$

$$H5 = 0$$

$$H4 = S_{ELEV}$$

$$H3 = H4 + H_{ISB}$$

$$H2 = H4 + H_{TSB}$$

$$H1 = H2 + 1000$$

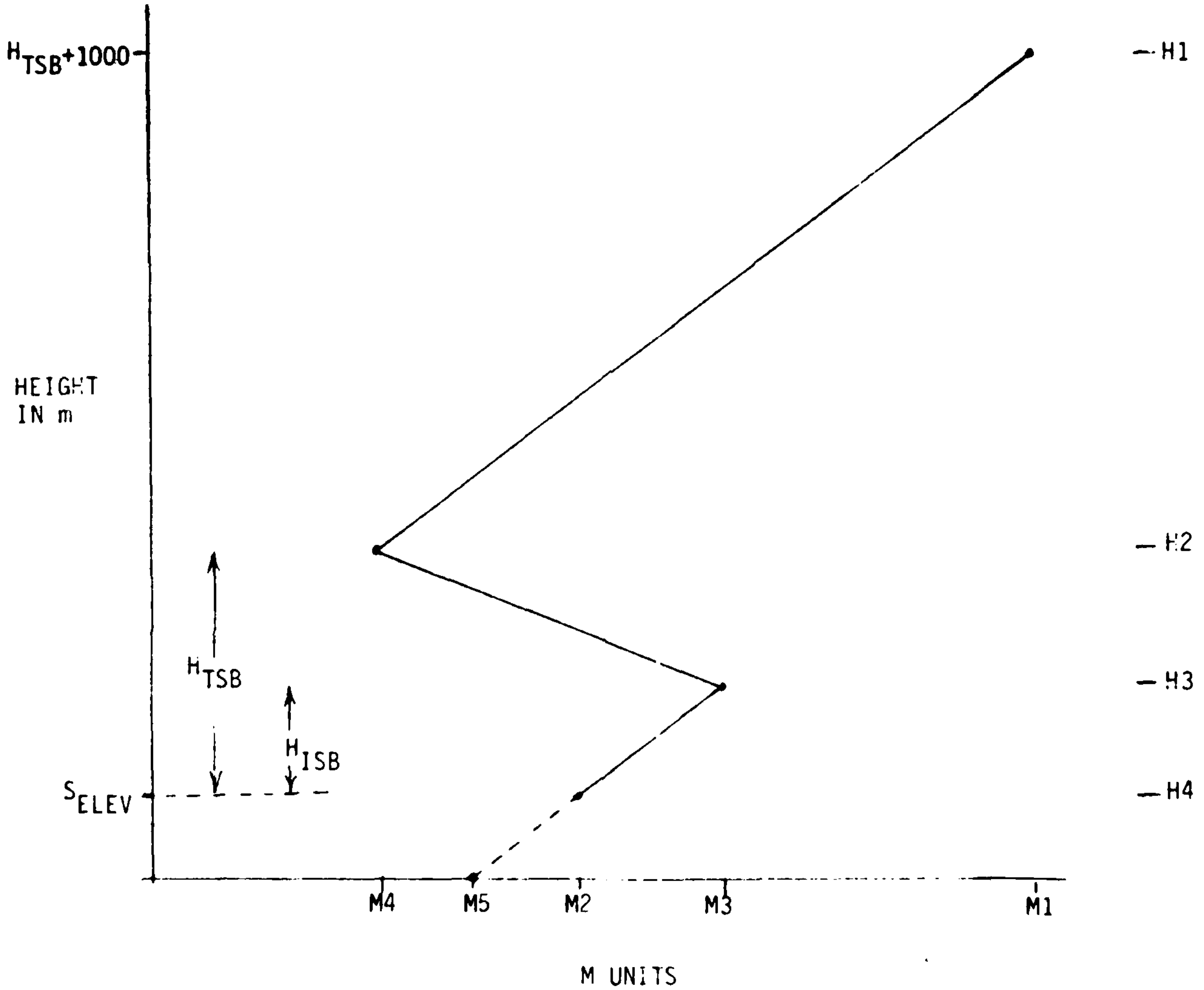


Figure 3.4.5-6. Surface Based Duct Only

$$Ni = Mi - \frac{Hi}{6.371} \qquad i = 1,2,3,4,5$$

3.4.5.8.2.3 Elevated Duct Only

This profile computation uses the following additional fields:

a. Median height of elevated duct inflection point above station (H_{IEL})

b. Median thickness of elevated duct (H_{TEL})

c. Median M Unit gradient below elevated duct inflection point (MG_{EL})

d. Median M Units deficit for elevated ducts (MD_{EL})

The arrays are filled with the five items computed below. Figure 3.4.5-7 identifies key points in the profile.

$$M4 = N_S + \frac{S_{ELEV}}{6.371}$$

$$M3 = M4 + \frac{MG_{EL}\ H_{IEL}}{1000}$$

$$M2 = M3 - MD_{EL}$$

$$M1 = M2 + MG_{1000}$$

$$M5 = M4 - 0.11772\ H4$$

$$H5 = 0$$

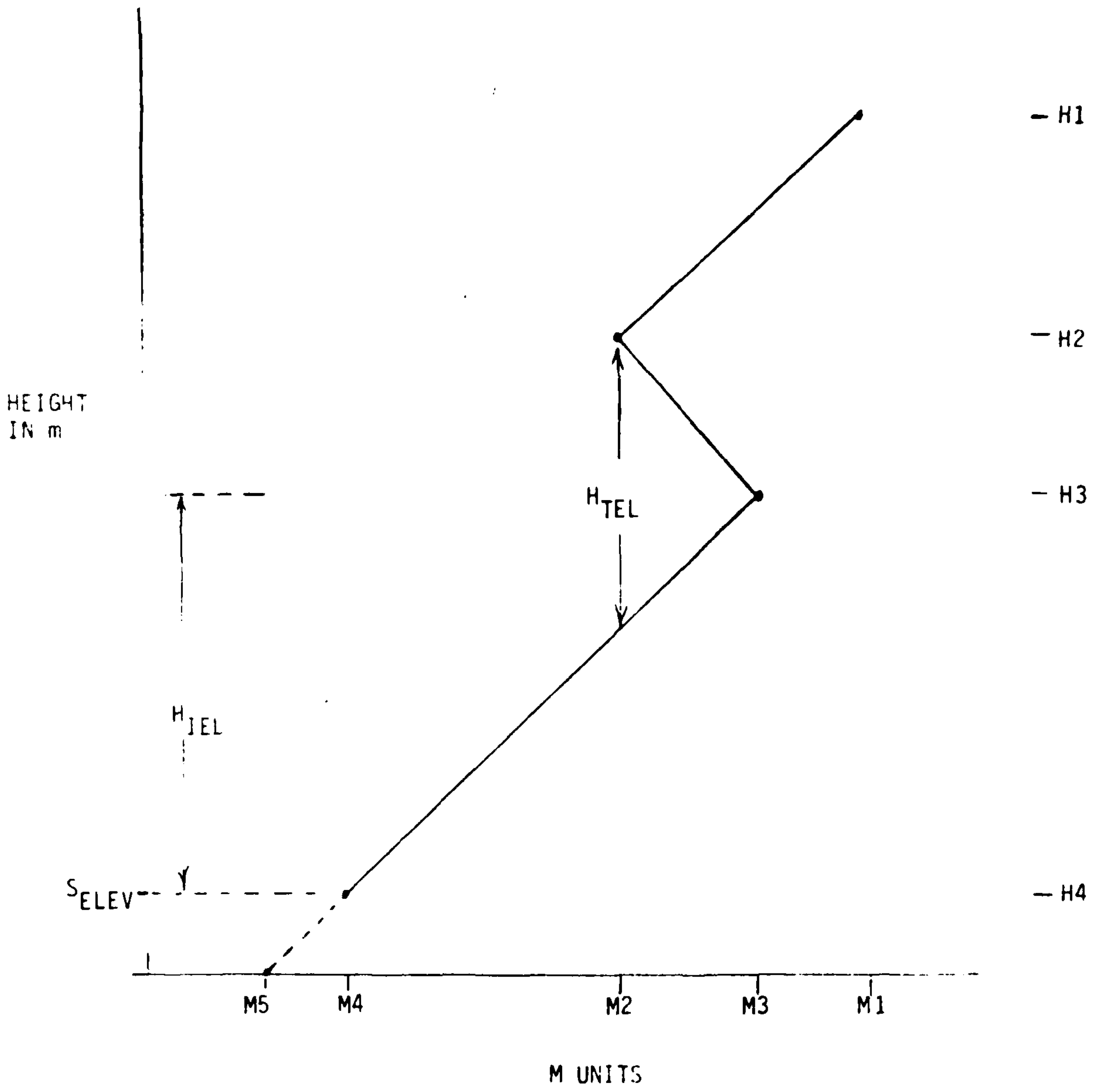


Figure 3.4.5-7. Elevated Duct Only

$$H4 - S_{ELEV}$$

$$H3 = H4 + H_{IEL}$$

$$H2 = H3 + H_{TEL} - \frac{MD_{EL}}{MG_{EL} \times 10^3}$$

$$H1 = H2 + 1000$$

$$N_i = M_i - \frac{H_i}{6.371} \qquad i = 1,2,3,4,5$$

3.4.5.8.2.4 Combined Surface Based and Elevated Ducts

The 7 values for the arrays are computed as indicated below. Figure 3.4.5-8 shows the important points in the profile.

$$M6 = N_S + \frac{S_{ELEV}}{6.371}$$

$$M5 = M6 + \frac{MG_{SB}\ H_{ISB}}{1000}$$

$$M4 = M5 - MD_{SB}$$

$$M3 = M4 - MG_{EL}\ \frac{H_{IEL} - H_{TSB}}{1000}$$

$$M2 = M3 - MD_{EL}$$

$$M1 = M2 + MG_{1000}$$

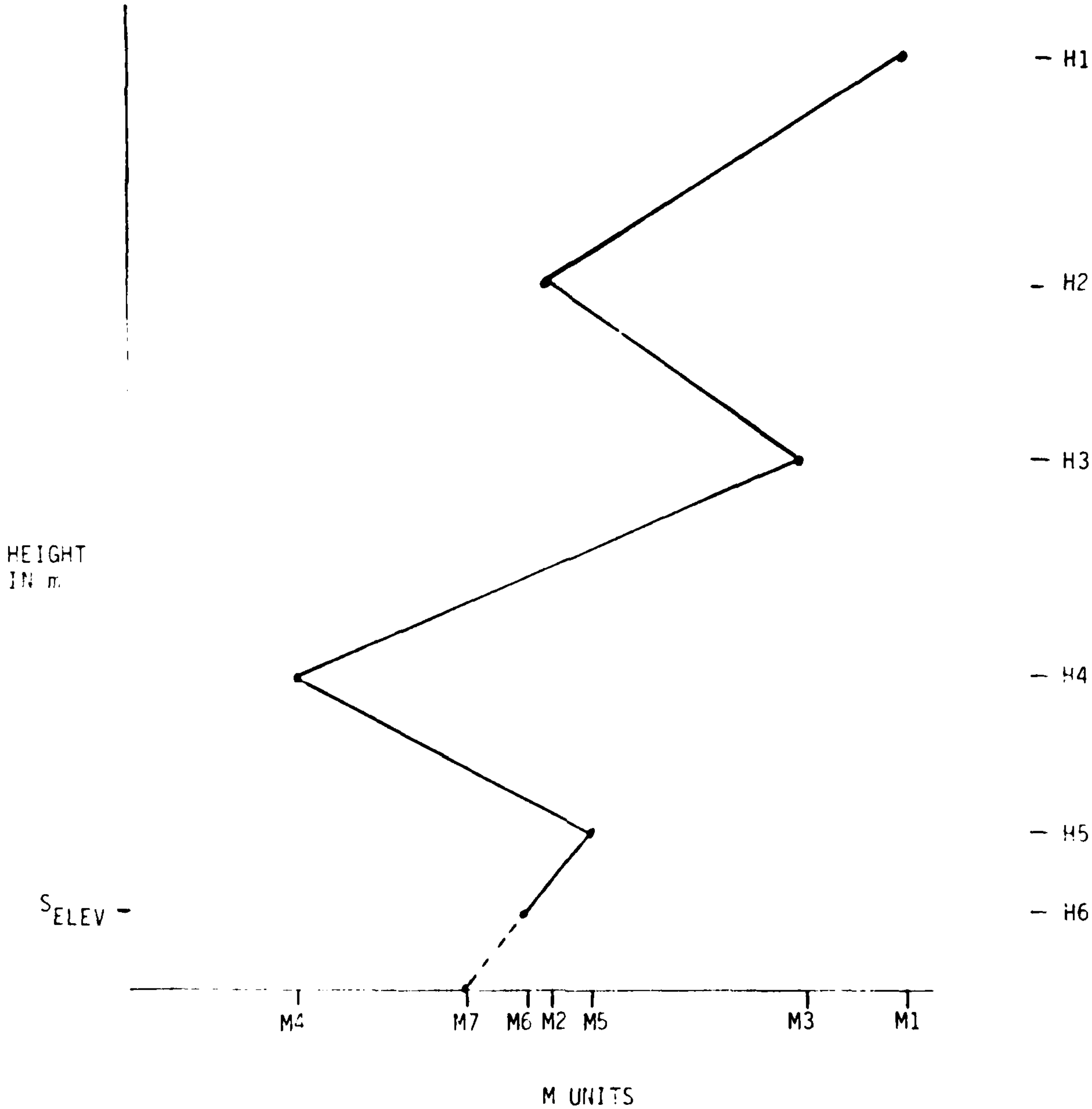


Figure 3.4.5-8. Combined Surface Based and Elevated Ducts

$$M7 = M6 - 0.11772\ H6$$

$$H7 = 0$$

$$H6 = S_{ELEV}$$

$$H5 = H6 + H_{ISB}$$

$$H4 = H6 + H_{TSB}$$

$$H3 = H6 + H_{IEL}$$

$$H2 = H3 + H_{TEL}\left(\frac{MD_{EL}}{MG_{EL} \times 10^3}\right)$$

$$H1 = H2 + 1000$$

$$Ni = Mi - \frac{Hi}{6.371} \qquad i = 1,2,3,4,5,6,7$$

3.4.5.8.3 Outputs

a. Height array

b. M Units array

c. N Units array

3.4.6 Initialize Function

The purpose of this function is to start the IREPS program from a "turn on" condition. A title and brief descriptive notes to the user are presented on the display as a result.

3.4.6.1 Title Subfunction

3.4.6.1.1 Inputs

None

3.4.6.1.2 Processing

The title as shown below is displayed to the operator.

**** IREPS ****

** Integrated Refractive Effects Prediction System **

The user commands (as listed in Table 3.4.6-1) are next displayed to the operator.

The operator is then prompted to enter the designation of the function to be run. In case of an erroneous entry, the Error Subfunction is referenced. The correctly selected function is loaded from the mass storage device and the Set-Up Subfunction is referenced. Then control is transferred to the Input Function (3.4.7).

3.4.6.1.3 Outputs

a. Operator Prompts

b. Operator Messages.

Table 3.4.6-1. User Commands

Command	Meaning
Back-Up	Return control to the preceding operator input prompt.
End	Entry is completed.
Options	Reference the Options Function immediately.
Disable Hardcopy	Disable hardcopy device.
Enable Hardcopy	Enable hardcopy device.
Mass Storage	Return mass storage media to start point.
Repeat	Repeat last output.
Restart	Restarts the program after a stop.
Default	Assigns the first option in parentheses or in the list as the desired selection.

3.4.6.2 Set-Up Subfunction

3.4.6.2.1 Inputs

None

3.4.6.2.2 Processing

This subfunction is called by the Title Subfunction.

The Set-Up Subfunction is used to initialize the default values of all variables and arrays. The lengths of character variables and dimensions for all arrays are established. All files are assigned symbolic names. Control is returned to the calling subfunction.

3.4.6.2.3 Outputs

None

3.4.6.3 Error Subfunction

3.4.6.3.1 Inputs

None

3.4.6.3.2 Processing

This subfunction is referenced by any other subfunction to display a message to the operator indicating that an invalid or erroneous response has been made in response to a prompt. A mass storage device error also causes a reference to this subfunction.

In case of a mass storage device error, this subfunction causes a fatal error after informing the operator that a malfunction has occurred with the mass storage device. Any diagnostic information available is also displayed to the operator, then the processor is halted.

3.4.6.3.3 Outputs

Message displayed to operator.

3.4.7 Input Function

The Input Function allows the operator to select one of the existing Environmental Data Sets for processing or to produce an entirely new data set. In setting up the data set the operator can protect it against being automatically overwritten. The information in an Environmental Data Set record is comprised of variables and arrays as listed below:

a. Variables

(1) Sequence number of this record in the environmental data set file - integer from 1 to 16

(2) Name - 24 ASCII character string (If the last character is an asterisk, this data set is protected)

(3) Location - 24 ASCII character string

(4) Time - 24 ASCII character string

(5) Type - Flag indicating the type of data set being created

(6) Height - Flag indicating units for height (feet or metres)

(7) Evap - Flag indicating whether or not evaporation duct parameters are entered

(8) WMO Height - 5 ASCII character string containing code group for height of the 1000 millibar surface

(9) Wind - Surface true wind speed in metres/second

(10) Sea - Surface sea temperature in degrees Celsius

(11) Air - Surface air temperature in degrees Celsius

(12) Relative Humidity - Surface relative humidity in percent

(13) Height Zero - Height offset or radiosonde launch height from mean sea level in metres

(14) Pressure Zero - station pressure at radiosonde launch height

(15) Nmax - Number of items in arrays

(16) Delta - Evaporation duct height in metres

(17) Change - Flag indicating that an extrapolated value of M and N units was calculated for a height of zero

b. Arrays

(1) WMO - WMO (World Meteorological Organization) message code groups

(2) Pressure - Pressure in millibars

(3) Temperature - Air temperature in degrees Celsius

(4) Relative Humidity - In percent

(5) Height - Height matrix in metres

(6) M Units - M unit array

(7) N Units - N unit array

The Input Function calculates the values for these variables and matrices based on operator inputs. This data file is then used by other functions in the IREPS Program. Individual procedures comprising the input function are described below.

3.4.7.1 Input Entry Subfunction

3.4.7.1.1 Inputs

File sequence array of existing Environmental Data Set record numbers from the Initialize Function (3.4.6).

3.4.7.1.2 Processing

Upon entry of the Input Function from the Initialize Function, the Setup Subfunction is referenced, then the list of existing Environmental Data Sets is displayed to the operator. If any of the data sets are protected, they are so identified on the display. The first slot available for placing a new data set on the mass storage data media is then found from the file sequence array input and a flag set to that value. If there are already 16 data sets, the first available unprotected data set is identified using a first-in-first-out (FIFO) queue. If the file array is completely filled with protected data sets, the flag is set to the maximum count of 16.

If there are no existing data sets, the operator is informed that no environmental data are stored and program control is transferred to the New Data Set Subfunction (3.4.7.4). If there are existing data sets, program control is transferred to the Data Set Subfunction.

3.4.7.1.3 Outputs

a. Existing Environmental Data Set listing.

b. Identification of protected data sets.

c. Flag set to first record number available for storing a new data set.

d. Notification if no Environmental Data Sets are stored.

3.4.7.2 Data Set Subfunction

3.4.7.2.1 Inputs

First available record number storage flag from Input Entry.

3.4.7.2.2 Processing

This subfunction is called by the input Entry Subfunction. A message requests the operator to enter the number of the Environmental Data Set desired. If the operator selects the "Back-Up" command, program control is returned to the Input Entry Subfunction. If the input is not valid, the Error Subfunction is called, and the operator is again requested to input the data set number.

If the operator enters a zero and the first available record number flag is not maximum, the program references the New Data Set Subfunction. If the flag is maximum, meaning that there is no record space available for the new data set, a message asks the operator to designate which protected data set is to be replaced. Entry of either the "Back-Up" command or zero returns control to the Input Entry Subfunction. Entry of an invalid value calls the Error Subfunction and prompts the operator to redesignate the data set to be replaced. A valid entry invokes the Read Record Subfunction (3.4.7.3).

3.4.7.2.3 Outputs

a. Message requesting number of data set to be read.

b. Message informing operator that maximum number of data sets exists.

c. Message requesting operator to designate which data set is to be replaced.

d. Sequence number of record to read from the Environmental Data Set file.

3.4.7.3 Read Record Subfunction

3.4.7.3.1 Inputs

Sequence number of record to read from Data Set Subfunction.

3.4.7.3.2 Processing

This subfunction is called by the Data Set Subfunction. The selected record is read from the mass storage device. During that interval a message is displayed informing the operator which record is being read. After reading the Environmental Data Set the program proceeds to the Options Subfunction (3.4.10). If end of file is reached on the mass storage device before the data is retrieved, the Error Subfunction is referenced followed by returning the control to the Input Entry Subfunction.

3.4.7.3.3 Outputs

All of the variables and arrays for one set of environmental data are read.

3.4.7.4 New Data Set Subfunction

3.4.7.4.1 Inputs

None

3.4.7.4.2 Processing

This subfunction is called by the Input Entry Subfunction. A header message "Environmental Data For IREPS", is presented followed by a request for the operator to select the type of data which will be entered.

a. Radiosonde

(1) Pressure, temperature, and relative humidity

(2) Ordinate values

b. M Units

c. N Units

d. WMO Message

e. Refractometer

If the "Back-Up" command is selected, the program returns to Input Entry Subfunction. An invalid selection causes the Error Subfunction to be referenced followed by another display requesting the data type. A valid entry displays a message confirming the type of data entry (the default is radiosonde). If radiosonde, M unit, or N unit data is selected the Height Units Subfunction is referenced. If WMO message data will be the input, the Location Subfunction (3.4.7.6) is referenced. A selection of refractometer data causes the Refractometer Function (3.4.12) to be executed.

3.4.7.4.3 Outputs

Flag set indicating type of input data.

3.4.7.5 Height Units Subfunction

3.4.7.5.1 Inputs

Type flag from New Data Set Subfunction.

3.4.7.5.2 Processing

This subfunction is called by the New Data Set Subfunction. The operator is requested to designate whether feet or metres will be used for units of height. (The default is feet.) If the "Back-Up" command is selected and the data type is refractometer, the Options Subfunction is referenced. If the "Back-Up" command is selected for any other data type, control returns to New Data Set. If an invalid selection is made, the Error Subfunction is referenced and the control is returned to the start of the Height Units Subfunction. A valid entry sets the height-units flag and displays a message to the operator confirming the selection. The Location Subfunction is then referenced.

3.4.7.5.3 Outputs

a. Message requesting selection of units for height

b. Confirming message

c. Height-units flag

3.4.7.6 Location Subfunction

3.4.7.6.1 Inputs

Input type flag from New Data Set.

3.4.7.6.2 Processing

This subfunction is called by the New Data Set and Height Units Subfunctions. A message requests the operator to enter a character string for the name of the location (default is "not specified"). If the "Back-Up" command is selected and data type is WMO message, control is returned to the New Data Set Function, otherwise the "Back-Up" command returns control to the Height Units Subfunction. The location that is entered is displayed and program control is routed to the Time Subfunction.

3.4.7.6.3 Outputs

a. Message requesting location character string

b. Message displaying location string

3.4.7.7 Time Subfunction

3.4.7.7.1 Inputs

None.

3.4.7.7.2 Processing

This subfunction is called by the Location Subfunction. The operator is prompted to enter a date and time string. The "Back-Up" command returns control to the Location Subfunction. (The default value for date and time is "not specified".) The date and time entered are displayed to the operator. The command is then transferred to the Wind Speed Subfunction.

3.4.7.7.3 Outputs

a. Message prompt to enter date and time string

b. Message displaying string entered

3.4.7.8 Wind Speed Subfunction

3.4.7.8.1 Inputs

None.

3.4.7.8.2 Processing

This subfunction is called by the Time Subfunction. A prompt message requests the operator to enter true wind speed in knots. Selecting the "Back-Up" command at this point returns control to the Time Subfunction. If the value entered for wind speed is less than zero or greater than or equal to 1000 the Error Subfunction is referenced followed by a return to the prompt message. The default value for wind speed is zero. If a value for wind speed within limits is entered, the value is displayed and stored in the wind variable of the Environmental Data Set. Units of this variable are m/s and conversion is accomplished with the formula

$$\text{Wind} = \frac{1.54432\ V}{3}\ \text{m/s}$$

where V = the operator entered value in knots.

Control is then transferred to the Evaporation Duct Parameters Subfunction.

3.4.7.8.3 Outputs

a. Message prompting operator to enter true wind speed

b. Message confirming entry data

c. Setting the wind speed variable to the entered value in m/s

3.4.7.9 Evaporation Duct Parameters Subfunction

3.4.7.9.1 Inputs

Data set type flag.

3.4.7.9.2 Processing

This subfunction is called by the Wind Speed Subfunction. The operator is queried whether evaporation duct parameters will be entered. (The default is "yes".) If the "Back-Up" command is selected control returns to the Wind Speed Subfunction. A "no" reply causes acknowledgement of the negative response, sets sea temperature, air temperature, and relative humidity to zero, and transfers control to the WMO Subfunction (3.4.7.14), if that is the type of data input. For any other type of data, transfer of control goes to the Profile Height and Pressure Subfunction (3.4.7.10) after the three variables are zeroed. If the reply is not "yes" or "no", the Error Subfunction is referenced and the operator receives another prompt message. A "yes" reply generates a message that the evaporation duct parameters are to be entered and displays a request to enter sea temperature in degrees Celsius. A "Back-Up" command returns to the entry message for evaporation duct parameters. If the condition $0^{o}C \leq$ sea temperature value $\leq 50^{o}C$ is not satisfied, the Error Subfunction is referenced and the entry prompt given again. The default value for sea temperature is $0^{o}C$. A valid entry is stored in the sea temperature variable of the data set.

A similar process is followed for entry of air temperature, except the data is stored in the air temperature variable and "Back-Up" returns control to sea temperature input. The value for air temperature must be within the units $-100^{o}C \leq$ value $\leq 100^{o}C$. Otherwise the Error Subfunction is referenced and the operator receives another prompt message. The default value is $0^{o}C$.

The relative humidity input is made the same way, except "Back-Up" returns control to air temperature entry. The value is a percentage between 0 and 100. The default value is 0 percent. Otherwise the Error Subfunction is referenced and the prompt message is displayed again. The value is stored in the relative humidity variable and the operator entry is displayed. If the data type flag is WMO message, control is given to that subfunction. For all other cases, control goes to the Profile Heights and Pressures Subfunction.

3.4.7.9.3 Outputs

a. Message asking whether evaporation duct parameters will be entered.

b. Prompts to enter sea temperature, air temperature, and relative humidity.

c. Setting of the values for the sea temperature, air temperature, and relative humidity variables.

3.4.7.10 Profile Heights and Pressures Subfunction

3.4.7.10.1 Inputs

Data set type flag.

3.4.7.10.2 Processing

This subfunction is called by the Evaporation Duct Parameters Subfunction. For all data set types except refractometer, the operator is prompted to enter a height value. If the type is not radiosonde, the operator is prompted to enter height offset from mean sea level (MSL). A "Back-Up" entry at this point takes the operator to the relative humidity input of the Evaporation Duct Parameters Subfunction, (3.4.7.9) if evaporation duct parameters were entered. Alternatively the control is returned to the Evaporation Duct Parameter Subfunction entrance. If the height offset is not between -100 and 2500m, the Error Subfunction is referenced followed by a return to the initial profile heights and pressures prompt. A valid entry is saved and echoed to the operator, and control is transferred to the Height and M or N Unit Entry Subfunction (3.4.7.12).

If the type of data set is radiosonde, the operator is prompted to enter the radiosonde launch height above mean sea level. A "Back-Up" entry at this point returns control to the relative humidity entry if evaporation duct parameters were entered or to the Evaporation

Duct Subfunction entry otherwise. An invalid entry of radiosonde launch height causes the Error Subfunction to be referenced followed by another prompt to enter radiosonde launch height. A valid data value is saved and echoed to the operator. Control is then transferred to the Station Pressure Subfunction.

3.4.7.10.3 Outputs

a. Prompt for operator to enter height offset or radiosonde launch height.

b. Message informing the operator of the height value accepted.

3.4.7.11 Station Pressure Subfunction

3.4.7.11.1 Inputs

None.

3.4.7.11.2 Processing

This subfunction is called by the Profile Heights and Pressures Subfunction. A prompt requests that the operator enter station pressure at the radiosonde launch height. A "Back-Up" entry returns control to the radiosonde launch height entry point in the Profile Heights and Pressures Subfunction. An invalid entry (not between 900 and 1200) references the Error Subfunction and causes a new prompt to enter pressure. A valid entry is saved and displayed to the operator. Control is then transferred to the Pressure Subfunction.

3.4.7.11.3 Outputs

a. Prompt to enter station pressure

b. Display of value entered

3.4.7.12 Height and M or N Units Subfunction

3.4.7.12.1 Inputs

Height units flag.

3.4.7.12.2 Processing

This subfunction is called by the Profile Heights and Pressures Subfunction. The operator is prompted to enter up to 29 values of height and M or N units by this subfunction. At least two entries must be made. Height must be entered in an increasing sequence. If the "Back-Up" entry is made control is transferred to the Profile Heights and Pressures Subfunction, if no height entries have been made. Otherwise the last height entry is deleted and the prompt displayed again.

As each height and M or N unit entry is made, it is checked for validity. If heights are not entered in increasing order the Error Subfunction is referenced, then the operator is prompted to make another entry. If the height entry is not between zero and 5×10^4 metres or the M or N unit entry is not between zero and 10^4, a reference is made to the Error Subfunction and another prompt issued.

Valid data is stored in the height and M units or N units arrays. Conversion is performed on either M and N unit data depending on the type of operator entry. The array value stored is

$$N_i = M-(H_i + H_o)/6.371$$

$$M_i = N+(H_i + H_o)/6.371$$

where N_i, M_i = value stored at item 1 in the array

N, M = operator entry

H_i = height entry in metres

H_o = height offset from mean sea level

The entered values are displayed to the operator after they have been stored.

If the operator attempts to terminate the height and M or N unit entry before the second set of values is entered, an error message is displayed which says not enough values have been entered, and the operator is prompted to enter another set.

After all the values have been entered, the operator terminates the input and the total number of data pairs entered is displayed. The operator is then given the option of protecting the data set. (Protected data sets may only be deleted when the operator directs. Unprotected data sets may be automatically deleted to make room for new ones.) A "Back-Up" command returns control to Evaporation Duct Parameter Subfunction if the data type is refractometer, otherwise "Back-Up" transfers to the prompt to enter the next height and M or N value pair. An invalid reply (not "yes" or "no") references the Error Subfunction and reissues the message.

If the data type in the arrays is refractometer, control is given to the Invert Subfunction (3.4.7.16). Otherwise the height is converted to metres and corrected for height offset by the formula

$$H_i = k\ H_i + H_o$$

where k = 1 if height was entered in metres

= 0.3048 if height was entered in feet

Then program control is transferred to the Invert Subfunction

3.4.7.12.3 Outputs

a. Operator prompt messages

b. Data pairs for the height and M units or N units arrays

3.4.7.13 Pressure Subfunction

3.4.7.13.1 Inputs

None

3.4.7.13.2 Processing

This subfunction is called by the Station Pressure Subfunction. The operator is queried as to whether the radiosonde data will be entered as ordinate values. A "yes" reply transfers control to the Baseline Subfunction (3.4.7.18). Otherwise the operator is prompted to enter up to 29 sets of data for pressure in millibars, temperature in ^{o}C, and percent relative humidity. At least two such entries must be made.

Pressure must be entered in a decreasing order. Otherwise the Error Subfunction is referenced followed by a new prompt to enter data. The same error routines are followed if the data entered is not within these limits:

$0 \leq$ Pressure ≤ 1200

$-100 \leq$ Temperature ≤ 100

$0 \leq$ Relative Humidity ≤ 100

Valid data is stored in the pressure, temperature, and relative humidity arrays and the values displayed to the operator.

When the operator terminates the entry, a check is made to verify that at least two sets of values have been entered. If not the operator is given another entry prompt. If enough values were entered, the total number accepted is displayed to the operator. The operator is next asked if the data set is to be protected. A valid reply ("yes" or "no") transfers control to the Convert Subfunction (3.4.7.15). An invalid reply references the Error Subfunction and generates a new prompt for data set protection.

3.4.7.13.3 Outputs

a. Operator prompts

b. Arrays containing pressure, temperature, and relative humidity data sets

3.4.7.14 WMO Data Subfunction

3.4.7.14.1 Inputs

None

3.4.7.14.2 Processing

This subfunction is called by the Evaporation Duct Parameters Subfunction. The purpose of this subfunction is to accept pressure, temperature, and dew point depression values in the WMO Radiosonde Code format of Federal Meteorological Handbook No. 4. The code groups appear as

$$\underbrace{nn}_{\text{index}}\ \underbrace{PPP}_{\text{pressure}} \qquad \underbrace{TTT}_{\text{temperature}}\ \underbrace{DD}_{\text{dew point depression}}$$

The operator is prompted to enter up to 30 code groups. A minimum of two groups must be entered.

First the index value of the next code group is computed by the formula

$$\text{index} = \left\{ 11 \quad \text{MOD10}\left[\text{INT}\left(\left| \frac{1-2}{9} \right| + I-1 \right)\right] \right\}$$

Where INT = integer function

MOD10 = modulus function base 10

I = index running from 1 to 30

This function generates an index value from zero through 99 in increments of 11. (If the index calculated is zero, it is converted to the ASCII string "00".) The index is displayed to the operator together with the prompt to enter the next code group.

If the "Back-Up" command is selected before any code group is entered, control returns to the Evaporation Duct Parameters Subfunction. Otherwise, the last code group entered is deleted and another prompt issued. If the operator enters the "END" command, the input is terminated and a check is made to ensure that a minimum of two levels was entered. (If not, a warning message is displayed and the operator is prompted to enter another value.)

The processing of each entry converts the WMO message code group to pressure, temperature, and relative humidity and stores the values in their respective arrays. The following algorithm is used.

Step 1. If the pressure <100 and the dew point depression code is not two slashes the pressure is incremented by 1000. If this is the first code group go to Step 3.

Step 2. If the previously entered pressure was less than or equal to 100, the current pressure value is divided by 10.

Step 3. If the temperature code (TTT) is an odd number, change the sign to negative.

Step 4. If the dew point depression code is two slashes, go to Step 6.

Step 5. Convert dew point depression code (DD) to relative humidity.

$$X = \frac{DD}{10} \qquad 50 \geq DD$$

$$X = DD-50 \qquad \text{otherwise}$$

compute dew point Temperature

T_d = TTT-DD

Compute environmental vapor pressure

$$E_{EVIRON} = 6.1078 \left(10^{7.5\ Td/(T_d + 237 \cdot 3)}\right)$$

Compute saturation vapor pressure

$$E_{SAT} = 6.1078 \left(10^{7.5\ TTT/(TTT + 237 \cdot 3)}\right)$$

$$\text{Relative humidity} = \frac{100\ E_{ENVIRON}}{E_{SAT}}$$

Go to Step 7.

Step 6. Relative humidity = 19

Step 7. If this is the first code group, set the environmental vapor pressure at the surface level (E_e) to $E_{ENVIRON}$.

Step 8. If relative humidity is less than 19, set it to 19. If this is the first code group go to Step 10.

Step 9. If the current pressure code group is greater than the previous one, reference the Error Subfunction, delete the entry, and prompt the operator for another code group.

Step 10. Check values are within limits. For any values exceeding these limits, reference the Error Subfunction, delete the entry and prompt the operator for a new code group.

Valid Limits

0< pressure <1200

-100 < temperature <100

0< relative humidity <100

Step 11. Save the pressure, temperature, and relative humidity values in the next item of their respective arrays. Display the level, WMO Radiosonde Code, pressure, temperature, and relative humidity to the operator.

After all WMO message values are stored, the display indicates the index number of the last level and sets the following system variables:

$$P_o = \text{Pressure (1)}$$

$$T_A = \text{Temperature (1)} + 273.2$$

$$T^* = T_A + \frac{0.3794017 T_A E_e}{P_o - E_e}$$

where P_o = Pressure zero

Pressure (1) = First item in the pressure array

T_A = Absolute air temperature

Temperature (1) = First item in the temperature array

T^* = Virtual temperature

Next the operator is queried whether the radiosonde launch height will be entered. If the "Back-Up" command is selected, control is returned to the beginning of the WMO Data Subfunction. If the operator replies "no", launch height is set to zero. A "yes" reply results in a prompt to enter launch height in metres. If an entry greater than or equal to zero is made, the value is accepted. Otherwise the Error Subfunction is referenced and another prompt given to the operator.

If the operator answered "no" to the launch height prompt, a message requesting the code group for the height of the 1000 millibar surface is displayed. A "Back-up" entry at this point takes the operator to the launch height prompt again. A five ASCII character string in the form

$$0\ 0\ \underbrace{H\ H\ H}_{\text{Height Code}}$$

must be entered. If the format is incorrect, the Error Subfunction is referenced followed by another prompt to enter the 1000 millibar surface. If the height code is greater than 500, it is decremented by 500. If the code is within the range

$$-500 < HHH \leq 500$$

the value is displayed and the variable, height zero, is set to

$$\text{height zero} = HHH-29.29T^{*} \ln \frac{P_o}{1000}$$

If the range for HHH is exceeded, the Error Subfunction is referenced and another prompt displayed.

The value of height zero is verified. If it is less than or equal to zero, an error message is displayed and the prompt issued again.

The operator is next asked if the data set is to be protected. If the "Back-Up" command is selected, control returns to the launch height prompt. If the reply is not "yes" or "no", the Error Subfunction is referenced and another prompt message displayed. Finally, the data type flag is set to indicate that WMO data has been stored. Control is transferred to the Convert Subfunction.

3.4.7.14.3 Outputs

a. Pressure, temperature, and relative humidity array values
b. Radiosonde launch height
c. Pressure zero
d. Absolute air temperature
e. Virtual temperature
f. Height zero
g. Data set type flag

3.4.7.15 Convert Subfunction

3.4.7.15.1 Inputs

Temperature relative humidity, and pressure arrays.

3.4.7.15.2 Processing

This subfunction is called by the Shift, WMO, and Pressure Subfunctions. This subfunction converts the input array values to arrays of height and M or N units. Each value is calculated by the following algorithm.

Step 1. Set H_0 to height zero

Step 2. Set P_o to pressure zero.

Step 3. Repeat Steps 4 through 11 for each set of data. The index runs from 1 to Nmax.

Step 4. Calculate absolute air temperature

$$T_A = T + 273.2$$

Step 5. Set $P_1 = P_i$

Step 6. Compute water vapor pressure in millibars

$$E_e = \frac{R_i \; 6.105 \exp \left\{ 25.22 \; (T_A - 273.2)/T_A - 5.31 \; \ln \frac{T_A}{273.2} \right\}}{100}$$

where R_i = the relative humidity array item.

$$T_1^* = T_A + 0.3794017 \; T_A \; E_e/(P_1 - E_e)$$

Step 7. If this is the first iteration (that is, i = 1) set

$$T_o^* = T_1^*$$

Step 8. Compute height

$$H_i = H_o + 14.63 \; (T_1^* + T_o^*) \ln(P_o/P_1)$$

Step 9. Compute M and N units

$$M_i = \frac{77.6 \; (P_1 + 4810 \; E_e/T_A)}{T_A} + \frac{H_i}{6.371}$$

$$N_i = M_i - \frac{H_i}{6.371}$$

Step 10. Set up variables for next iteration

$H_o = H_i$

$P_0 = P_1$
$T_0^* = T_1^*$

Step 11. Go to Step 4.
Transfer control to the Invert Subfunction upon completion.

3.4.7.15.3 Outputs

Arrays containing height, M units, and N units.

3.4.7.16 Invert Subfunction

3.4.7.16.1 Inputs

Height, M units, and N units array.

3.4.7.16.2 Processing

This subfunction is called by the Convert and Height and M or N Units Subfunctions. This subfunction inverts the order of the height, M units, and N units array to put heights in decreasing order. If nc entry for a height of zero was made by the operator, an extrapolated value for M at the zero height (at array item number Nmax) is computed by the following:

$$M_{Nmax} = M_{Nmax-1} - \frac{0.75\ H_{Nmax}}{6.371}$$

where M_{Nmax-1} = next to last item in the inverted M units array

H_{Nmax} = last height value in the inverted array.

Then a corresponding N_{Nmax} is found

$N_{Nmax} = M_{Nmax}$

The Delta Subfunction is next referenced.

3.4.7.16.3 Outputs

Inverted height, M units and N units arrays. Change flag set to indicate whether or not extrapolated values were completed for the M and N values at a height of zero.

3.4.7.17 Delta Subfunction

3.4.7.17.1 Inputs

a. Air temperature

b. Sea temperature

c. True wind speed

d. Relative humidity

3.4.7.17.2 Processing

This subfunction calculates the evaporation duct height (δ) with the following algorithm.

Step 1. Set δ to zero. If evaporation duct parameters were not entered by the operator go to step 14.

Step 2. Convert temperatures to absolute
T_A = Air temperature + 273.2
T_S = Sea temperature + 273.2

Step 3. Convert wind speed to knots

$U = 3W/1.54432$

where W = true wind speed in m/s

Step 4. Compute the bulk Richardson's number

$$R_{ib} = \frac{2214(T_A - T_S)}{T_A U^2}$$

Step 5. If $R_{ib} > 1$ then set it to 1

$$e_s = 6.105 \exp\left(25.22 \frac{T_A - 273.2}{T_A} - 5.31 \ln \frac{T_A}{273.2}\right)$$

$$e_o = 6.105 \exp\left(25.22 \frac{T_S - 273.2}{T_S} - 5.31 \ln \frac{T_S}{273.2}\right)$$

$$e_e = \frac{e_s\ RH}{100}$$

where RH = relative humidity

Step 6. Compute ΔN

$$\Delta N = \frac{77.6}{T_A}\left[1000 + \frac{4810}{T_A} e_e\right] - \frac{77.6}{T_A}\left[1000 + \frac{4810}{T_A} e_o\right]$$

Step 7. Compute Γ

$\Gamma = 0.05$	$R_{ib} \leq -3.75$
$\Gamma = 0.065 + 0.004\ R_{ib}$	$-3.75 < R_{ib} \leq -0.12$
$\Gamma = 0.109 + 0.367\ R_{ib}$	$-0.12 < R_{ib} \leq 0.14$
$\Gamma = 0.115 + 0.012\ R_{ib}$	$0.14 < R_{ib}$

Step 8. Compute $Z_{1/L}$.

$$\frac{Z_1}{L} = \frac{R_{ib}}{10}\text{, where } Z_1 = 6 \text{ metres}$$

Step 9. If $R_{ib} \geq 0$ go to Step 12.

Step 10. Compute Ψ

$$\Psi = 4.5 \frac{L_1}{L'} \qquad \frac{Z_1}{L'} \geq -0.1$$

$$\Psi = 10^{1.02 \log(-\frac{Z_1}{L'}) + 0.69} \qquad -0.01 > \frac{Z_1}{L'} \geq -0.26$$

$$\Psi = 10^{0.776 \log(-\frac{Z_1}{L'}) + 0.306} \qquad -0.26 > \frac{Z_1}{L'} \geq -0.100$$

$$\Psi = 10^{0.630 \log(-\frac{Z_1}{L'}) + 0.16} \qquad -0.100 > \frac{Z_1}{L'} \geq -1$$

$$\Psi = 10^{0.414 \log(-\frac{Z_1}{L'}) + 0.16} \qquad -1 > \frac{Z_1}{L'} \geq -2.2$$

$$\Psi = 2 \qquad \frac{Z_1}{L'} < -2.2$$

Step 11. Begin to compute δ

$$B = \ln \frac{6}{1.5\times10^{-4}} - \Psi$$

$$D = \left(\frac{-0.125B}{\Delta N}\right)^4 - 18\left(\frac{-0.125B}{\Delta N}\right)^3 \left(\frac{R_{ib}}{60?}\right)$$

If $D > 0$ then set $\delta = D^{-0.25}$. Go to Step 14.

Step 12. If $\Delta N \geq 0$ go to Step 14.

Step 13. Continue computation of δ.

$$B = \ln\left(\frac{6}{1.5\times10^{-4}}\right) + 5.2 \frac{Z_1}{L'}$$

$$\delta = \frac{\Delta N}{-0.125B - 5.2\Delta N\left(\frac{R_{ib}}{60?}\right)}$$

If $\delta \geq 0$ and $\frac{\delta R_{ib}}{60\Gamma} \leq 1$ go to Step 14.

$$\delta = \frac{6.2\Delta N + 3.9}{-0.125 \ln\left(\frac{6}{1.5 \times 10^{-4}}\right)}$$

Step 14. If $\delta > 40$ then set δ to 40.

Step 15. Transfer control to the Store Profile Data Subfunction.

3.4.7.17.3 Outputs

Evaporation duct height.

3.4.7.18 Store Profile Data Subfunction

3.4.7.18.1 Inputs

All environmental data set variables and arrays.

3.4.7.18.2 Processing

This subfunction is called by the Delta Subfunction. This subfunction stores the data set in the next available file on the mass storage device. If the operator so designates, the data set is flagged as a protected file. A maximum of 16 data sets can be stored. If there are already 16 data sets on the mass storage device, this subfunction will search for a candidate data set to delete. The first unprotected data set (the one with the lowest file number) found will be replaced by the new one. The following data elements comprise each data set (see 3.4.7).

a. Variables

(1) File number at which the data set is stored
(2) Name of data set
(3) Location
(4) Time
(5) Type
(6) Height
(7) Evap
(8) WMO height
(9) Wind
(10) Sea
(11) Air
(12) Relative humidity
(13) Height zero
(14) Pressure zero
(15) Number of items in each array
(16) Delta
(17) Change flag

b. Arrays

(1) WMO message
(2) Pressure
(3) Temperature
(4) Relative humidity
(5) Height
(6) M units
(7) N units
(8) Environmental Sequence
(9) Cover System Sequence
(10) Loss System Sequence

Finally the Options Function (3.4.10) is referenced.

3.4.7.18.3 Outputs

Data to mass storage device.

3.4.7.19 Baseline Subfunction

3.4.7.19.1 Inputs

None.

3.4.7.19.2 Processing

This subfunction is called by the Pressure Subfunction. This subfunction allows the operator to enter temperature and relative humidity ordinates directly from the recorder strip chart. This subfunction then computes temperature and relative humidity dependent upon the baseline check information entered by the operator. The pressure-contact setting is not used in the computations, but it is included in the data list for archival and quality control purposes. The sounding data is entered as time in minutes and tenths, pressure in millibars, and temperature ordinate and relative humidity ordinate for each level. This subfunction requires the operator to enter a level within the -37^{o} to -40^{o}C temperature range as the final measurable relative humidity level. For temperatures less than -40^{o}C, for which no relative humidity is reported, the appropriate value to enter for the relative humidity ordinate is 85.

This subfunction can be used in two ways: (1) the operator can enter only the significant levels as determined manually, or (2) the operator can enter up to 100 levels without regard for significance and the program will determine the significant levels. After the last level has been entered, the operator is asked if this subfunction is to check for significant levels. If the response is "yes" then this subfunction will select only those levels required to reproduce the sounding to within ± 1°C (± 2°C above 100 mb) and ± 10%. All other levels will be deleted. If the operator replies "no" this subfunction assumes all levels entered are significant.

The Environmental Data Set allows a maximum of 29 significant levels. Therefore, any levels above level 29 will be deleted when the data is stored in the Environment Data Set.

The operator is prompted to enter the pressure-contact setting, temperature ordinate, baseline temperature ordinate, relative humidity ordinate, and baseline relative humidity. In each case entry of an invalid entry causes the Error Subfunction to be referenced followed by another prompt. The valid limits for each parameter, default values, and point to which control is transferred upon entry of the "Back-Up" command are listed in Table 3.4.7-1.

Table 3.4.7-1. Entry Parameters

Parameter	Valid Limits	Default	A "Back-up" Command Transfers Control to
Pressure-Contact Setting	Entry > 0	None	Profile Heights and Pressures Subfunction
Baseline Temperature Ordinate	$0 \leq$ Entry ≤ 100	0	Pressure Contact Setting Entry
Baseline Temperature Entry	$-80 \leq$ Entry < 100	0	Baseline Temperature Ordinate
Baseline Relative Humidity Ordinate	$0 \leq$ Entry < 100	0	Baseline Temperature Entry
Baseline Relative Humidity	$0 \leq$ Entry < 100	0	Baseline Relative Humidity Ordinate Entry

The baseline temperature is converted to absolute

$$\text{BASE T} = \text{BASE } T_e + 273.2$$

Where

$$\text{Base } T_e = \text{Operator Entry}$$

A 50% relative humidity ordinate value is computed to be used in later conversions of temperature and relative humidity ordinates to temperature and relative humidity.

Step 1. $I1 = \exp(16.0082991 - 0.9966256 \ln[(2)(\text{Base T Ord})] - 48{,}000$

Where

Base T Ord = Baseline temperature ordinate entry

Step 2. $X = 5.3018981 \left(\frac{1}{303} - \frac{1}{\text{Base T}} \right)$

$Y = -2.47991 \times 10^{-3} + (6.1499536 \times 10^{-6} - 2.359944\ X$

$\times\ 10^{-4})^{1/2}$

$$Z = \frac{Y}{1.179972 \times 10^{-4}}$$

$$I2 = \frac{14{,}000}{I1} \exp(Z)$$

Step 3. Temp = Base T

$I5 = 10\ (\text{Base RH Ord} - 500)$

where

Base RH Ord = Baseline relative humidity ordinate entry

Step 4. Ordinate = 0

Step 5. DEL = 1

DELTA = 10

Last ΔRH = 100

Step 6. j = 1

Step 7. i = 1

Step 8. $\text{Ordinate} = \text{Ordinate} + \frac{1}{\text{DEL}}$

RH Const = 10 Ordinate - 500

Reference the Relative Humidity Subfunction (3.4.7.21)

$$\Delta RH = |RH - \text{Base RH}|$$

where

RH = output of the Relative Humidity Subfunction

Base RH = Baseline Relative Humidity Entry

Step 9. If $\Delta RH \leq$ DELTA go to Step 12.
If Last $\Delta RH - \Delta RH \geq 0$ go to Step 10.
DEL = -DEL.

Step 10. Last $\Delta RH = \Delta RH$

Step 11. Increment i. If $i \leq 100$ go to Step 8.

Step 12. DEL = 10 DEL
$\text{DELTA} = \frac{\text{DELTA}}{10}$

Step 13. Increment j. If $j \leq 3$ go to Step 7.

Step 14. RH Const = 10 Ordinate - 500.
The 50% ordinate value (ordinate) is then printed and control is transferred to the Ordinate Values Subfunction.

3.4.7.19.3 Outputs

a. Operator prompts

b. Pressure-contact setting

c. Baseline temperature ordinate

d. Baseline temperature

e. Baseline relative humidity ordinate

f. Baseline relative humidity

g. 50% ordinate value

3.4.7.20 Ordinate Values Subfunction

3.4.7.20.1 Inputs

a. Pressure zero (Pr zero)

b. Surface air temperature (Air)

c. Surface relative Humidity (Relhm)

3.4.7.20.2 Processing

This subfunction is called by the Baseline Subfunction. This subfunction provides for entry of up to 100 levels of elapsed time, pressure, temperature ordinate, and relative humidity ordinate.

Step 1. Set Level check = 0. Set the first item in each working array.
Presur (1) = Pr zero
Temper (1) = Air
Relhum (1) = Relhm

Step 2. i = 1

Step 3. Increment i. If i = 100 go to Step 18.

Step 4. The operator is prompted to enter the elapsed time, pressure, temperature ordinate, and relative humidity ordinate. If the "Back-Up" command is entered and i=2 transfer control to the base relative humidity entry in the Ordinate Value Subfunction. If the "Back-Up" command is entered and i > 2, go to Step 4. If the "End" command is entered go to Step 18.

Step 5. Check the entries for validity. If not within these ranges:

$0 \leq$ Pressure $<$ 1200 and Presur (I-1) $<$ Pressure

$0 <$ Temperature ordinate $<$ 100

$0 \leq$ Relative humidity ordinate $<$ 100

reference the Error Subfunction and issue another prompt.

Step 6. Save values in arrays

E time(i) = Time entry

Presur(i) = Pressure

Temp Ord(i) = Temperature ordinate

RH Ord(i) = Relative humidity ordinate

Step 7. I3 = exp[(16.0082991 - 0.9966256 ln (2 Temp Ord(i)] - 48,000

$$X = \ln\left[\frac{(I2)(I3)}{14,000}\right]$$

$$I4 = \frac{1}{(303)^{-1} + 4.6774\ I4 \times 10^{-4} + 1.11278\ I4^{2} \times 10^{-5}}$$

Temper(i) = I4-273.2

Temp = Temper(i)

where I2 is computed in Step 2 of Section 3.4.7.19.

Step 8. If RH Ord(i) $\geq$ 85 and Temper(i) $<$ -40 go to Step 10.

Step 9. I5 = 10 RH Ord(i) -500

Reference the Relative Humidity Subfunction.

Relhm(i) = RH

where

RH = output of the Relative Humidity Subfunction.

Go to Step 11.

Step 10. Relhum(i) = 19

Step 11. If Temper(i) > -37 go to Step 16.

Step 12. If Temper(i) $\leq$ -37 and Temper(i) $\geq$ -40 then set Level check=1.

Step 13. If Level check =1, go to Step 15.

Step 14. Display the "A significant level is required between -37^{o} and -40^{o}C" message, then go to Step 4.

Step 15. If Temper(i) < -40 go to Step 16. Otherwise display the values of i, time entry, pressure, temperature ordinate, Temper(i), relative humidity ordinate, and Relhum(i). Go to Step 3.

Step 16. Display i, time entry, pressure, temperature ordinate, and Temper(i). Go to Step 3.

Step 17. Decrement i. Go to Step 4.

Step 18. Set the number of items in the arrays (Nmax) to i-j. If Nmax > 1 go to Step 19. Display the "Not enough levels" error message and go to Step 4.

Step 19. Display the "End of profile" message and the value of Nmax. Transfer control to the Significants Subfunction.

<u>3.4.7.20.3 Outputs</u>

a. Time array

b. Pressure array

c. Temperature array

d. Relative humidity array

3.4.7.21 Relative Humidity Subfunction

3.4.7.21.1 Inputs

a. Temporary variable (I5)

b. Relative humidity constant (RH Const)

c. Air temperature (Temp)

3.4.7.21.2 Processing

This subfunction is called by the Ordinate Values Subfunction.

Step 1. If I5 > 60 go to Step 3.

Step 2. $X = 8.4079 \text{ RH Const} \times 10^{-2} - 9.2007 \text{ I5} \times 10^{-2} + 0.12687 \text{ Temp} + 1.3426(\text{I5})(\text{RH Const}) \times 10^{-4}$

$Y = X - 7.4676 \text{ I5}^4 \times 10^{-10} + 3.702(\text{Temp})(\text{I5}^3) \times 10^{-10} - 2.5669 [(\text{RH Const})(\text{I5})]^3 \times 10^{-5}$

$RH = Y + 4.7002 \text{ I5}^6 \times 10^{-15} + 46.706.$

Go to Step 5.

Step 3. $X = 0.10489 \text{ RH Const} + 2.0422 \text{ I5}^3 \times 10^{-6} - 1.4068 \text{ RH Const}^2 \times 10^{-4} + 5.0362 \text{ RH Const} \times 10^{-4}$

$Y = X + 2.8783(\text{RH Const})(\text{Temp}) \times 10^{-4} - 1.208 \text{ I5}^2 \times 10^{-3} + 2.9083(\text{Temp})(\text{RH Const}^3) \times 10^{-9}$

$Z = Y - 4.2336(\text{Temp})(\text{I5}^3) \times 10^{-9} + 9.3054[(\text{RH Const})(\text{I5})]^3 \times 10^{-15}$

$RH = Z - 1.8825 \text{ I5}^6 \times 10^{-14} + 42.082$

Step 4. If 28 > RH $\geq$ 16, subtract 2 from RH.

Step 5. If RH < 19, set RH to 19.

Transfer control to the Significants Subfunction.

3.4.7.21.3 Outputs

Relative humidity (RH)

3.4.7.22 Significants Subfunction

3.4.7.22.1 Inputs

a. Pressure array (Presur)

b. Temperature array (Temper)

c. Relative humidity array (Relhum)

d. Number of items in the arrays (*Nmax*)

3.4.7.22.2 Processing

This subfunction is called from the Relative Humidity and Baseline Subfunctions. Query the operator whether this subfunction is to check for significant levels. A "Back-Up" command transfers control to the Ordinate Value Subfunction. A "no" reply transfers control to the Shift Subfunction (3.4.7.24). An invalid reply causes the Error Subfunction to be referenced followed by another prompt. A "yes" reply starts the processing.

The surface level and the level of termination of the sounding are always significant. Additionally, a significant level must be placed within the -37°C to -40°C range as the final measurable humidity level. Intervening levels will be selected as significant wherever the temperature or humidity curve between the least significant level and successively higher levels equals or exceeds 1°C in temperature (2°C above 100 mb) or 10 percent in relative humidity. A profile composed of the significant levels should reproduce the original sounding within 1°C (2°C above 100 mb) and 10 percent relative humidity. Transfer control to the Sort Subfunction.

3.4.7.22.3 Outputs

Significant array (Sig)

3.4.7.23 Sort Subfunction

3.4.7.23.1 Inputs

a. Significant array (Sig)
b. Elapsed time array (E time)
c. Pressure array (Presur)
d. Temperature array (Temper)
e. Temperature ordinate array (Temp Ord)
f. Relative humidity array (Relhm)
g. Relative humidity ordinate array (RH Ord)

3.4.7.23.2 Processing

This subfunction is called from the Significants Subfunction. Delete insignificant levels.

Step 1. For any insignificant level, delete the corresponding level from all arrays and move the levels above down one item in the arrays.

Step 2. Print the time, pressure, temperature ordinate, temperature, relative humidity, and relative humidity for each significant level. (If Temper(i) < -40 the Relative humidity ordinate and Relative humidity are not printed.) Transfer control to the Shift Subfunction.

3.4.7.23.3 Outputs

Arrays containing only significant levels.

3.4.7.24 Shift Subfunction

3.4.7.24.1 Inputs

a. Elapsed time array (E time)

b. Pressure array (Presur)

c. Temporary ordinate array (Temp Ord)

d. Temperature array (Temper)

e. Relative humidity array (Relhum)

3.4.7.24.2 Processing

This subfunction is called from the Significants and the Sort Subfunctions. This subfunction moves data from working arrays to the permanent arrays for use in other IREPS functions. The transfer is limited to the lowest 29 items in the working arrays. Then control is transferred to the Convert Subfunction (3.4.7.15).

3.4.7.24.3 Outputs

a. Pressure array

b. Temperature array

c. Relative humidity array

d. Elapsed time array

e. Temperature ordinate array

f. Relative humidity ordinate array

3.4.7.25 Set-Up Subfunction

3.4.7.25.1 Inputs

None

3.4.7.25.2 Processing

This subfunction is called by the Input Entry Subfunction. The Set-Up Subfunction is used to initialize the default values of all variables and arrays. The lengths of character variables and dimensions for all arrays are established. All files are assigned symbolic names. Control is returned to the calling subfunction.

3.4.7.25.3 Outputs

None

3.4.7.26 Error Subfunction

3.4.7.26.1 Inputs

None

3.4.7.26.2 Processing

This subfunction is referenced by any other subfunction to display a message to the operator indicating that an invalid or erroneous response has been made in response to a prompt. A mass storage device error also causes a reference to this subfunction.

In case of a mass storage device error, this subfunction causes a fatal error after informing the operator that a malfunction has occurred with the mass storage device. Any diagnostic information available is also displayed to the operator, then the processor is halted.

3.4.7.26.3 Outputs

Message displayed to operator.

3.4.8. List Function

The purpose of the List Function is to print the environmental data list primarily for checking numeric values of data entries that provide dew point depression, altitude, N units, N unit gradients, M units, and a description of the refractive conditions. Figure 3.4.8-1 is a sample listing.

```
                    **** ENVIRONMENTAL DATA LIST ****

LOCATION: 31 56N  118 36W
DATE/TIME: 17 JUN 00452

WIND SPEED 12.0 KNOTS                     EVAPORATION DUCT PARAMETERS:
                                          SEA TEMPERATURE 18.2 DEGREES C
                                          AIR TEMPERATURE 15.1 DEGREES C
                                          RELATIVE HUMIDITY 89 PERCENT
                                           EVAPORATION DUCT HEIGHT   28.0 FEET
                                           EVAPORATION DUCT HEIGHT    8.5 METRES
SURFACE PRESSURE = 1008.0 mB
RADIOSONDE LAUNCH HEIGHT = 60.0  FEET
```

LEVEL	PRESS (mB)	TEMP (C)	RH (%)	DEW PT DEP(C)	FEET	N UNITS	N/Kft	M UNITS	CONDITION
0	------	----	----	----	0.0	340.7	-12.0	340.7	NORMAL
1	1,008.0	15.1	89.0	1.8	60.0	340.0	-28.2	342.9	SUPER
2	1,000.0	14.2	87.0	2.1	281.6	333.8	15.6	347.2	SUB
3	993.0	13.9	95.0	.8	476.6	336.8	-10.9	359.6	NORMAL
4	982.0	13.3	97.0	.5	785.3	333.4	-176.4	371.0	TRAP
5	972.0	20.4	25.0	20.8	1,071.8	282.9	27.2	334.2	SUB
6	962.0	21.5	34.0	16.6	1,364.9	290.9	-28.9	356.2	SUPER
7	949.0	21.5	27.0	19.9	1,751.3	279.7	-9.4	363.5	NORMAL
8	862.0	20.6	25.0	20.8	4,477.3	254.0	-9.5	468.2	NORMAL
9	850.0	19.7	25.0	20.7	4,873.5	250.2	-7.6	483.4	NORMAL
10	807.0	20.0	25.0	20.7	6,339.1	239.0	-6.0	542.3	NORMAL
11	726.0	14.5	34.0	15.8	9,299.4	221.2	-8.9	666.1	NORMAL
12	700.0	11.8	34.0	15.5	10,305.6	212.2	------	705.3	------

SURFACE REFRACTIVITY: 341 --SET SPS-48 TO 344

Figure 3.4.8-1. Typical Environmental Data List

3.4.8.1 Listing Subfunction

3.4.8.1.1 Inputs

3.4.8.1.2 Processing

This subfunction is called by the Options Function. This subfunction first initializes the height factor to 1 if the output is in metres, or to 1/0.3048 for output in feet. The title of the listing is printed followed by the source of the data (if derived from WMO message or refractometer data).

Next the location, date, and time are printed. The wind speed in knots or metres per second is printed next. If evaporation duct parameters are selected the sea temperature, air temperature, relative humidity, and duct height are printed. If the type of data is not refractometer or WMO message, the height offset from mean sea level is printed.

The main body of the report is printed next. For each level in the refractivity arrays, the following data is provided:

a. Pressure - mb
b. Temperature - ^{o}C
c. Relative humidity - percent
d. Dewpoint depression - ^{o}C
e. Height - ft or m
f. N units
g. N units gradient
h. M units
i. Refractivity condition

In the case of the latter field the options are based on the value of the N units gradient.

$$\text{Dndh} = 304.8 \frac{N_{i-1} - N_i}{H_{i-1} - H_i} \quad \text{N units per 1000 feet}$$

where

N_i, N_{i-1} = values in N units array

H_i, H_{i-1} = values in height array (metres)

i = index of current layer

The refractivity condition is found based on Dndh as follows:

Sub	Dndh > 0
Normal	$0 \geq$ Dndh > -24
Super	$-24 \geq$ Dndh > -48
Trap	$-48 \geq$ Ddnh

The surface refractivity in N units and SPS-48 setting (see 3.4.13.3.2) conclude the output. Control is then transferred to the Options Function (3.4.10).

3.4.8.1.3 Outputs

Environmental data listing

3.4.9 Loss Function

The Loss Function provides a path loss versus range plot. See Figure 3.4.9-1. Inputs to this function include an Environmental Data Set record, a Loss System Data Set, height of the transmitting or radar antenna, and the height of the target or receiving antenna. Loss plots for either airborne or surface-based microwave platforms can be provided.

The loss plot for surface-based systems can account for up to four regions as listed below:

a. The optical interference region is dominated by coherent interference between direct and sea-reflected waves. This region is always within the radio horizon.

b. The diffraction field region applies to ranges somewhat greater than the radio horizon. The loss in this region is due to diffraction around the earth's surface. This loss can usually be represented as a single waveguide mode solution to the series equation which describes the electric field in this region.

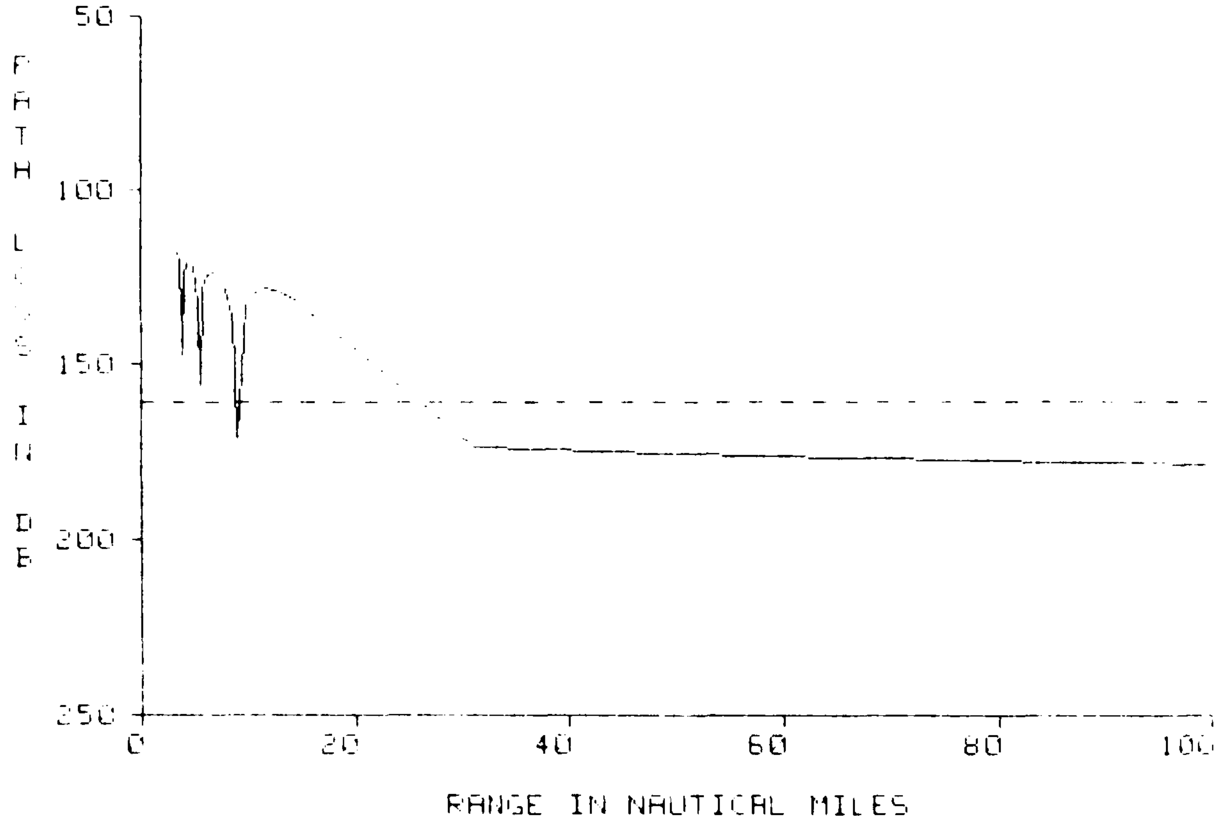
c. The intermediate region accounts for the transition between the optical interference and diffraction field regions. In the intermediate region, the actual solution for the electric field strength is very complicated, so a linear interpolation method of solution is used.

d. The troposcatter region occurs at ranges well beyond the radio horizon, and the electric field in this region is primarily due to scattering from irregularities of the refractive index in the troposphere.

**** LOSS DISPLAY ****

SPS-10 DD

LOCATION: BERMUDA
DATE TIME: 16 JULY 79 12Z



SURFACE-SEARCH RADAR
BASED ON 50 % POD OF DESTROYER-SIZED SURFACE TARGET

DASHED LINE INDICATES DETECTION, COMMUNICATION, OR INTERCEPT THRESHOLD

FREE SPACE RANGE: 248.0 NAUTICAL MILES
FREQUENCY: 5600 MHZ
TRANSMITTER RADAR HEIGHT: 131.0 FEET
RECEIVER TARGET HEIGHT: 50.0 FEET

Figure 3.4.9-1

Typical Loss Display

The loss plots for airborne systems provide line-of-sight ranges only (tangent ray limited). No two-ray interference, diffraction, or troposcatter calculations are made for these plots. The plots are analogous to the coverage diagrams for airborne systems described in 3.4.2.

The discussion which follows assumes that the reader is familiar with material presented in NOSC TN 669 and NELC TN 3037. Furthermore, the reader should carefully distinguish between the two height variables used in these calculations:

Ht - The transmitter or radar antenna height

Hr - The target or receiving antenna height

3.4.9.1 Loss Entry Subfunction

3.4.9.1.1 Inputs

a. ASCII array containing the names of up to 32 EM systems.

b. Loss System Data Set

3.4.9.1.2 Processing

Upon entry to this subfunction, the Setup Subfunction is referenced and the Command Array is zeroed. The names of the EM systems stored in the input array are next displayed to the operator. If the array is empty, an error message is printed and the Options Function is called. Otherwise a message requests the operator to identify the radar system desired. (The default is the first one.) If the "Back-Up" command is entered, control is transferred to the Options Function. If the operator chooses a valid radar system number, its parameters are read from the Loss System Data Set. Otherwise, the Error Subfunction is called and the operator is given another opportunity to specify the radar system. Once the Loss System Data Set has been read, the Loss Plot Subfunction is referenced

The following variables comprise the Loss System Data Set:

a. Radar Name - 24 ASCII character string.

b. Display - Flag indicating range and units of the loss plot.

c. Platform Type - Flag indicating whether platform is surface or airborne.

d. Antenna - Antenna height in metres.

e. Frequency - Frequency in MHz.

f. Free Space - Free space range in km.

g. Antenna Type - Flag indicating antenna directional pattern.

h. Beamwidth - Antenna vertical beamwidth in degrees.

i. Elevation - Antenna elevation angle in degrees.

j. Security - Security classification of the system.

k. Label - Two line (80 ASCII characters each) label for plots.

3.4.9.1.3 Outputs

a. Name of system in the array.

b. Operator prompts.

3.4.9.2 Loss Plot Subfunction

3.4.9.2.1 Inputs

a. Display flag indicating range and units of loss plot.

b. Command file array item which stores the number of loss plots required in the Auto-Mode.

c. Platform type flag.

d. Antenna height variable.

3.4.9.2.2 Processing

This subfunction is called by the Loss Entry Subfunction. If the operator enters the "Options" command, control is transferred to that function. Otherwise height and range conversion factors are set according to whether the display flag indicates that the plot is to be in units of nautical miles or kilometres. If the height units are feet, and range is in nautical miles, the height conversion factor is 0.3048, and the range conversion factor is 1.85. Otherwise, both the height and range conversion factors are 1.0, height units are metres, and range is in kilometres. These conversion factors are only used to convert units for the operator display. All internal storage and computations are carried out in mks units. If the program is in Auto-Mode, Ht and Hr have already been set by the Auto-Mode Function (see 3.4.1). Otherwise, if the platform type is surface, the transmitter height (Ht) is set to the antenna height. If the platform type is airborne, the operator is requested to enter the transmitter height (the default value is zero). If the operator issues the "Back-Up" command, control is transferred to the start of the Loss Entry Subfunction. If the operator enters a value greater than 20,000 metres or less than 0.9 metre, the Error Subfunction is referenced and the operator is again requested to enter the transmitter height. The entry of the receiver/target height (Hr) is made in the same manner for either surface or airborne platforms.

The maximum range of the plot is set according to the value of the display flag. See Table 3.4.9-1. If the flag indicates that operator should enter the maximum range (plot type G), he is requested to do so. If the operator enters the "Back-Up" command, the start of the Loss Entry Subfunction is given program control. If the operator enters a range between 5 and 1000 nautical miles, the value is accepted. Otherwise, the Error Subfunction is called and the operator is again requested to enter the range.

Table 3.4.9-1. Loss Plot Maximum Ranges

Type of Plot	Maximum Range
A	200 nm
B	100 nm
C	50 nm
D	400 km
E	200 km
F	100 km
G	*Operator Entry

* Limits: 5 to 1000 nm

3.4.9.2.2.1 Surface Platform Ray Trace Setup

For surface platforms only, the constants and arrays to be used in the ray trace are initialized next. Also a determination is made as to whether or not the Environmental Data indicates the presence of a surface duct. The values of Ht and Hr are compared, and if

$$Ht \geq Hr$$

the values are interchanged and a flag set. (Setting Hr to the larger value is a convenience in the ray tracing algorithms.) The values in the height array (see 3.4.7) are compared with Ht. The item number of the first height in the array greater than Ht, referred to hereafter as i, is saved. (If all height array values are less than or equal to Ht, the item number saved is one.)

Next the first item in a 32 item array which will contain heights (in m) in increasing order of all M profile layers is set to Ht. (This array will be referred to as Hmrs.) Similarly, the first item in the 32 item array (referred to as Dmdh) containing $\frac{dM}{dH}$ times 10^{-3} for each layer in the M profile is set to

$$\text{Dmdh}(1) = \frac{\left(\text{M units}_i - \text{M units}_{i+1}\right) \times 10^{-3}}{\text{Height}_i - \text{Height}_{i+1}}$$

where Dmdh(1) = first item in the Dmdh array

M units_i, M units_{i+1} = items i and i+1 of M Units array (see 3.4.7)

Height_i, Height_{i+1} = items i and i+1 of height array (see 3.4.7)

Other arrays and variables are also set to initial values:

The first item in the Twodm array is

$$\text{Twodm}(1) = 2\times10^{-6}\,(\text{Height}_i - \text{Ht})\,\text{Dmdh}(1)$$

The M unit value at Ht is

$$\text{Rmatht} = 2\text{x}10^{-6}\ (\text{M units}_i - \text{Twodm}(1))$$

If the value of i is one, control is next transferred to determine the minimum angle not trapped (3.4.9.3.2.2 below). Otherwise, the items in the Hmrs array are filed as follows:

$$\text{Hmrs}_j = \text{Height}_k \qquad \begin{array}{l} j = 2,3,4,\ldots,i \\ k = 2,3,4,\ldots,i-j+2 \end{array}$$

The values in the Dmdh array are set to 10^{-3} times the slope ($\frac{dM}{dH}$) of each layer in the Height array

$$\text{Dmdh}(j) = \frac{(\text{M units}_{k-1} - \text{M units}_k)\text{x}10^{-3}}{\text{Height}_{k-1} - \text{Height}_k} \qquad \begin{array}{l} j = 2,3,4,\ldots,i \\ k = 2,3,4,\ldots,i-j+2 \end{array}$$

3.4.9.2.2.2 Determine Minimum Angle Not Trapped

For surface platforms only, the minimum value of the modified index of refraction in M units (Rmin) is found in the M units array. If this minimum value is less than Rmatht, there is no ducting region and the minimum-angle-not-trapped (Ttrap) is set to -1.57 radians. Otherwise, this angle is set to

$$\text{Ttrap} = 10^{-3}[2(\text{Rmatht} - \text{Rmin})]^{1/2} + 10^{-6}$$

If a trapping layer is present, the effective earth's radius factor (K) based on the first layer is found.

$$K = 1/2 \qquad \text{Adndh} > 1$$
$$= (1 + \text{Adndh})^{-1} \qquad -0.8 < \text{Adndh} \leq 1$$
$$= 5 \qquad \text{Adndh} < -0.8$$

where by definition

$$K = \frac{1}{1 + a\frac{dN}{dH}}$$

where N = index of refraction of the atmospheric layer

a = mean earth radius (6371 Km)

$\frac{dN}{dH}$ = gradient of this layer

The specific algorithm to be used is

$$\text{Adndh} = \frac{\text{M units}_{N-1} - \text{M units}_{N} - H}{H}$$

N = maximum number of items in the M Units and Height arrays

$H = \text{Height}_{N-1}/6.371$

If no trapping layer is present, the effective earth radius factor (K) based on ray trace is found instead by the following algorithm.

Step 1. The approximate grazing angle where the path length difference between the direct and sea reflect rays is equal to 1/4 wavelength

$$\psi_4 = \left[\frac{37.5}{f(3Ht^2 + (6371K)^2 Ht \times 10^3)}\right]^{1/2}$$

where

f = frequency in MHz

Step 2. The effective earth radius (Ae) in the lowest layer is 6371K km. The limiting grazing angle in the optical region with a standard atmosphere is

$$= \frac{0.01957}{(Kf)^{1/3}}$$

Step 3. If

$$\Psi_4 < \Psi$$

then Ψ is set equal to Ψ_4.

Step 4. At this point the values of Ht and Hr are compared. If they are equal the algorithm terminates.

Step 5. The elevation angle of the ray, α, is found

$$\alpha = \Psi^2 - \left[\Psi^2 + \frac{2Ht}{(6371K)^2 \times 10^3} \right]^{1/2} \quad \text{radians}$$

Step 6. The Surface Trace Subfunction (3.4.9.7) is referenced for a surface ray trace.

Step 7. K is found

$$\Delta H = Hr - Ht$$

$$\Delta M = 10^3 \left[\frac{-2\Delta H\alpha}{R} + \frac{2 \times 10^{-3} \Delta H}{R^2} \right]$$

where R = range returned by the Surface Trace Subfunction

$$K = 1/2 \qquad Adndh > 1$$

$$= (1 + Adndh)^{-1} \qquad -0.8 \leq Adndh \leq 1$$

$$= 5 \qquad Adndh < -0.8$$

where $\quad Adndh = \frac{6.371 \Delta M}{\Delta H} - 1$

Step 8. Repeat Step 2 one time.

3.4.9.2.2.3 Constants for Loss Algorithms

For surface platforms only, additional parameters are calculated. The distance to the radio horizon is

$$Horizon = 3.572 \left[(KHt)^{1/2} + (KHr)^{1/2} \right] \text{ in kilometers.}$$

The minimum difraction field range is

$$Dmin = Horizon + \frac{230.2 K^{2/3}}{f^{1/3}} \text{ km}$$

The rms ocean wave height is

$$\overline{h} = 5.1 \text{ Wind}^2 \times 10^{-3} \text{ m}$$

where Wind = true wind speed in m/s

3.4.9.2.2.4 Antenna Pattern Constants

The calculations in this paragraph apply to both surface and air platforms. The non-range dependent portion of the free space path loss in dB is

$$Fsterm = 32.45 + 8.686 \ln(f)$$

A logarithmic form of the frequency is also computed

$$Tlfq = 4.343 \ln(f)$$

The types of antennas modeled in the antenna pattern determination are listed in Table 3.4.9-2.

Table 3.4.9-2. Antenna Type

Type	Code
Omnidirectional or isotropic	O
Sinx/x	S
Cosecant-squared	C
*Height-Finder	H

* Note: Height-Finders are phased arrays which electronically step the beam in elevation. The antennas are modeled as $\frac{\sin x}{x}$, except the beam is swept upward by substituting the elevation angle of the direct ray for the elevation angle of the antenna.

The minimum range is set in terms of the maximum

$$Rmin = \frac{Rmax}{20}$$

The antenna factor and maximum elevation angle depend on the type of antenna as listed in Table 3.4.9-3.

Table 3.4.9-3. Antenna Factors and Maximum Elevation Angles

Type	Antenna Factor	Maximum Elevation Angle (degrees)
0	1	60
C	Antfac	1.745×10^{-2} (Beamwidth + Elevation) for surface platforms 1.745×10^{-2} (Elevation) for air platforms
H	Antfac	90
S	Antfac	$\tan^{-1}\left\{\dfrac{\pi\left[1-\dfrac{\pi}{\mathrm{Antfac}}\right]^{1/2}}{\mathrm{Antfac}}\right\} + 1.745 \times 10^{-2}$ (Elevation)

where

$$\mathrm{Antfac} = \sin \frac{1.745 \times 10^{-2}\,\mathrm{Beamwidth}}{2}$$

Control is transferred to the Diffraction and Troposcatter Field Constants Subfunction (3.4.9.3) for surface platforms, and to the Plot and Label Axes Subfunction (3.4.9.4) for air platforms.

3.4.9.2.3 Outputs

a. Constants and arrays for ray trace (surface platforms only).

b. Minimum angle not trapped (surface platforms only).

c. Effective earth's radius based on the first layer.

d. Limiting grazing angle in the optical region with a standard atmosphere.

e. Elevation angle of the ray.

f. Minimum diffraction field range.

g. Rms ocean wave height.

h. Antenna pattern constants.

3.4.9.3 Diffraction and Troposcatter Field Constants Subfunction

3.4.9.3.1 Inputs

a. The horizon range

b. The effective earth radius factor based on the M profile or ray trace (K).

c. The effective earth radius based on the lowest layer (Ae).

d. Ht

e. Hr

f. M unit array

g. Array containing 10^{-3} times the change in modified refractivity for each layer (Dmdh)

h. Evaporation duct height (δ)

3.4.9.3.2 Processing

This subfunction is called by the Loss Plot Subfunction. This subfunction is used only for surface-based systems. A search is made through the M Units array to find if a ground based duct exists which includes Ht. The top of the duct is the point at which the M profile reaches a minimum, Mmin. See Figure 3.4.9-2. The bottom of the duct can be computed using the formula

$$\text{Hmin} = \frac{M_{min} - M_n}{\text{Dmdh}(n)}$$

where n = the layer at which $\frac{dM}{dH}$ went positive.

M_n = M units array value for the n layer

Dmdh(n) = Dmdh array entry for the n layer

If a ground-based duct containing Ht as described above is found, height-gain factors are calculated using empirical models developed at NOSC (see NOSC TN 669). These computations are in terms of $\frac{Ht}{D}$. (If $\frac{Ht}{D}$ is less than 0.1, this term is set to 0.1.)

The transmitter/radar height-gain in dB is

$$F(Ht) = 8.686 \ln\left(\sin \frac{\pi Ht}{D}\right) \qquad 0.1 \leq \frac{Ht}{D} \leq 0.8$$

$$F(Ht) = 1.55\left(\frac{Ht}{D}\right)^{-5.57} - 10 \qquad 0.8 < \frac{Ht}{D}$$

The receiver/target height-gain is given in terms of $\frac{Hr}{D}$. (If $\frac{Hr}{D}$ is less than 0.1, this term is set to 0.1.) The receiver/target height-gain in dB is

$$F(Hr) = 8.686 \ln\left(\sin \frac{\pi Hr}{D}\right) \qquad 0.1 \leq \frac{Hr}{D} \leq 0.8$$

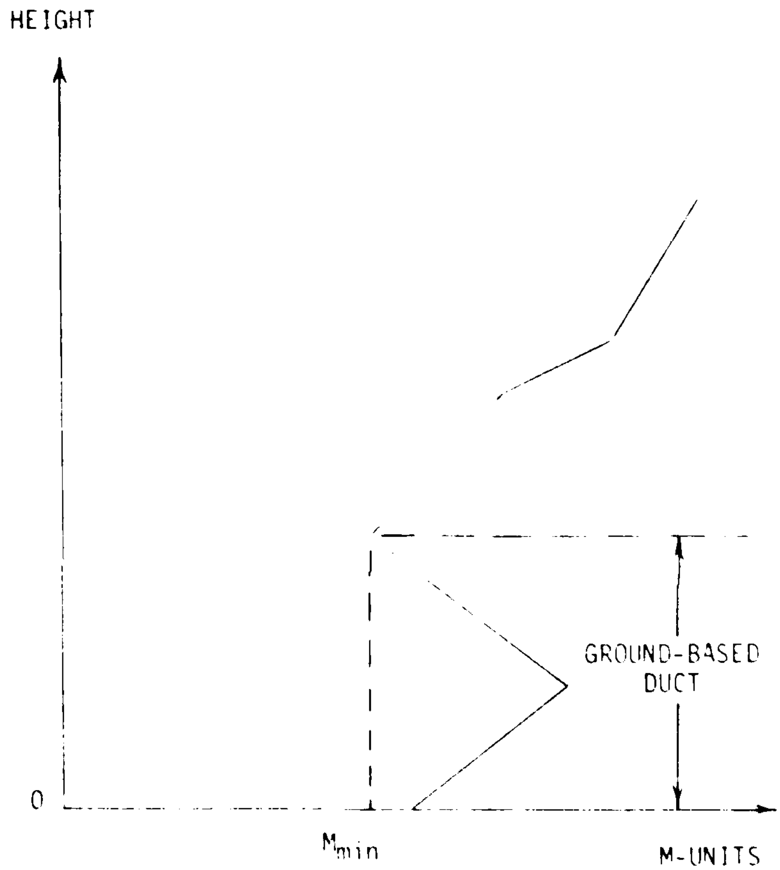


FIGURE 3.4.9-2

DUCT PARAMETERS

$$F(Hr) = 1.55\left(\frac{Hr}{D}\right)^{-5.57} - 10 \quad 0.8 < \frac{Hr}{D}$$

The non-range dependent loss in the diffraction region is found

$$Difac = 65 + Tlfq - F(Ht) - F(Hr)$$

where $Tlfq = 4.343 \ln(f)$

The attenuation rate in the diffraction region is set to 0.012 dB/km.

If no ground-based duct (as described above) is found, the height-gain factors for an evaporation duct are computed. The model used to calculate the height-gain functions for the evaporation duct uses a curve fit to a single-mode waveguide solution at 9.6 GHz. To use this model at other frequencies, the ranges must be scaled by

$$Rfac = 4.705 \times 10^{-2} f^{1/3}$$

and heights must be scaled by

$$Zfac = 2.214 \times 10^{-3} f^{2/3}$$

After Rfac and Zfac are calculated, the scaled Ht, Hr, and evaporation duct heights are computed using Zfac. These are Zt, Zr, and Del, respectively.

$$\begin{aligned} Zt &= \frac{1}{Zfac} & \frac{1}{Zfac} &> (Ht)(Zfac) \\ &= (Ht)(Zfac) & &\text{otherwise} \end{aligned}$$

$$Zr = \frac{1}{Zfac} \qquad \frac{1}{Zfac} > (Hr)(Zfac)$$

$$= (Hr)(Zfac) \qquad \text{otherwise}$$

$$Del = \delta\, Zfac$$

where δ = evaporation duct height (see 3.4.7.16.2)

If the scaled duct height is greater than 23.3 metres, it is reset to 23.3 metres.

If the duct height is between 10.24 and 23.3 metres (a well trapped mode), the following parameters are calculated for the scaled duct height.

$$C1 = -0.1189\ Del + 5.5495$$

$$C3 = \left[1.3291 \sin(0.218(Del - 10)^{0.77})\right] + 0.2171 \ln(Del)$$

$$C4 = 87 - \left[313.29 - (Del - 25.3)^2\right]^{1/2}$$

$$C5 = \frac{Fmax}{(Hlm)^{C6}}$$

$$C6 = \frac{(Hlm)(Slope)}{Fmax}$$

$$C7 = 49.4 \exp[-0.1699(Del-10)] + 30$$

where

$$Hlm = \frac{4 \exp[-0.31\ (Del-10)] + 6}{4.72}$$

$$slope\ \frac{1.5(C1)(C3)\ Hlm^{1/2}}{\tan(C3\ Hlm^{3/2})}$$

$$Fmax = C1 \ln \left[\sin\left(C3\ Hlm^{3/2}\right)\right] + C4 - C7$$

The height-gains are then computed. The Ht height-gain is

$$F(Zt) = C1 \ln \left[\sin \left[C3 \left(\frac{Zt}{4.72}\right)^{3/2}\right]\right] + C4 \qquad Zt \leq 4.7\ Hlm$$

$$F(Zt) = C5 \left(\frac{Zt}{4.72}\right)^{C6} + C7 \qquad Zt > 4.72\ Hlm$$

The Hr height-gain is

$$F(Zr) = C1 \ln \left[\sin \left[C3 \left(\frac{Zr}{4.72}\right)^{3/2}\right]\right] + C4 \qquad Zr \leq 4.72\ Hlm$$

$$F(Zr) = C5 \left(\frac{Zr}{4.72}\right)^{C6} + C7 \qquad Zr > 4.72\ Hlm$$

If the scaled evaporation duct height is less than 10.24 metres, the following parameters are computed.

$$C1 = -2.20 \exp(-0.244\ Del) + 17$$

$$C2 = [4.062361 \times 10^4 - (Del + 4.4961)^2]^{1/2} - 201.0128$$

$$C3 = -33.9 \exp(-0.517\ Del) - 3$$

$$C4 = [1.43012 \times 10^4 - (Del + 5.32545)^2]^{1/2} - 119.569 \quad .$$

$C5 = 41 \exp(-0.41\ Del) + 61$

Then the height-gain functions for Ht and Hr are calculated

$$F(Zt) = C1 \left(\frac{Zt}{4.72}\right)^{C2} + C3 \left(\frac{Zt}{4.72}\right)^{C4} + C5$$

$$F(Zr) = C1\left(\frac{Zr}{4.72}\right)^{C2} + C3\left(\frac{Zr}{4.72}\right)^{C4} + C5$$

For all scaled evaporation duct heights, the attenuation rate in dB/km is found as follows:

$$At = 92.516 - \left[8608.7593 - (Del-20.2663)^2\right]^{1/2}$$

If At is less than 9×10^{-4}, it is set to 9×10^{-4}. The attenuation is then

Attenuation = (Rfac) (At) in dB/km.

The excitation factor in dB (Tlm) is computed

$Tlm = 216.7 + 1.5526\ Del \qquad Del \leq 3.8$

$Tlm = 222.6 - 1.1771\ (Del-3.8) \qquad Del > 3.8$

and the non-range dependent loss in the diffraction field region is computed using the formula

$Difac = 51.1 + Tlm - F(Zt) - F(Zr) + 4.343 \ln (Rfac)$

Regardless of whether a ground based duct or evaporation duct was used in the computations above, the tropospheric scattering parameters are calculated using the formulas developed by Yeh. (See NOSC TN 669.)

$Tfac = 0.08984/K$

$$\text{Trofac} = 3\text{Tlfq} - 0.2 \text{ M Units}_N + 114.9 - (\text{Tfac})(\text{Horizon})$$

where

M Units_N = last item in the M Units array

Control is then transferred to the Plot and Label Axes Subfunction.

3.4.9.3.3 Outputs

a. The height-gains for Ht and Hr.

b. Attenuation rate in dB/km.

c. Non-range dependent loss in the diffraction region.

d. Scaled duct height parameters (only for an evaporation duct).

e. Tropospheric scattering parameters.

f. Operator prompts.

3.4.9.4 Plot and Label Axes Subfunction

3.4.9.4.1 Inputs

a. Range units for x-axis

b. Platform type

c. Maximum range for x-axis (Rmax)

3.4.9.4.2 Processing

This subfunction is called by the Diffraction and Troposcatter Field Constants and the Loss Plot Subfunctions. This subfunction establishes and labels the axes for the loss plot. See Figure 3.4.9-1. The Y-axis limits are 50 to 250 dB with tick marks every 50 dB. The X-axis limits are zero to the maximum range entered by the operator

(Rmax). There are five equally spaced tick marks on the X-axis. The X-axis units will be either nautical miles or kilometres as previously specified by the operator. Labels as shown in Figure 3.4.9-1 are put on each axis. If the platform is surface, control is transferred to the Loss for Surface Systems Subfunction. For air platforms, control is transferred to the Loss for Airborne Systems Subfunction (3.4.9.12).

3.4.9.4.3 Outputs

Plot axes and labels on the operator display.

3.4.9.5 Loss For Surface Systems Subfunction

3.4.9.5.1 Inputs

a. Maximum range of plot

b. Frequency

c. Effective earth's radius factor (K)

e. Ht and Hr

f. Limiting grazing angle in the optical region

g. Effective earth radius (Ae)

h. Minimum angle not trapped (Trap)

i. Minimum elevation angle (α_{max})

j. Minimum range in diffraction field region (D_{min})

3.4.9.5.2 Processing

This subfunction is called by the Plot and Label Axes Subfunction. This subfunction finds the first peak in the optical region which occurs when the total phase change between the direct and reflected rays (θ) is an even multiple of π ($0, 2\pi, 4\pi, \ldots$). If Ht is in a ground based duct, the first peak associated with

$$\alpha > T_{trap}$$

where

α = angle at the antenna of the direct ray

is used. (Refer to NOSC TN 669 and NELC TN 3037.) Figure 3.4.9-3 shows the first peak in the optical region, as well as other key areas, on the loss plot.

Shown in Figure 3.4.9-3 are several key points, each of which is defined below:

a. OPLOSS - loss at the last point (maximum range) in the optical region

b. OPMAX - the maximum range of the optical region

c. DMIN - range at which the diffraction region begins

d. LDMIN - the loss at the beginning of the diffraction region

The limiting grazing angle in the optical region, Ψ, is used to compute OPMAX

$$OPMAX = \frac{\left\{\left[(\Psi^2 + 2QHt)^{1/2} + (\Psi^2 + 2QHr)^{1/2}\right] - \Psi\right\} \times 10^{-3}}{Q}$$

where $Q = 1.5679 \times 10^{-7}$

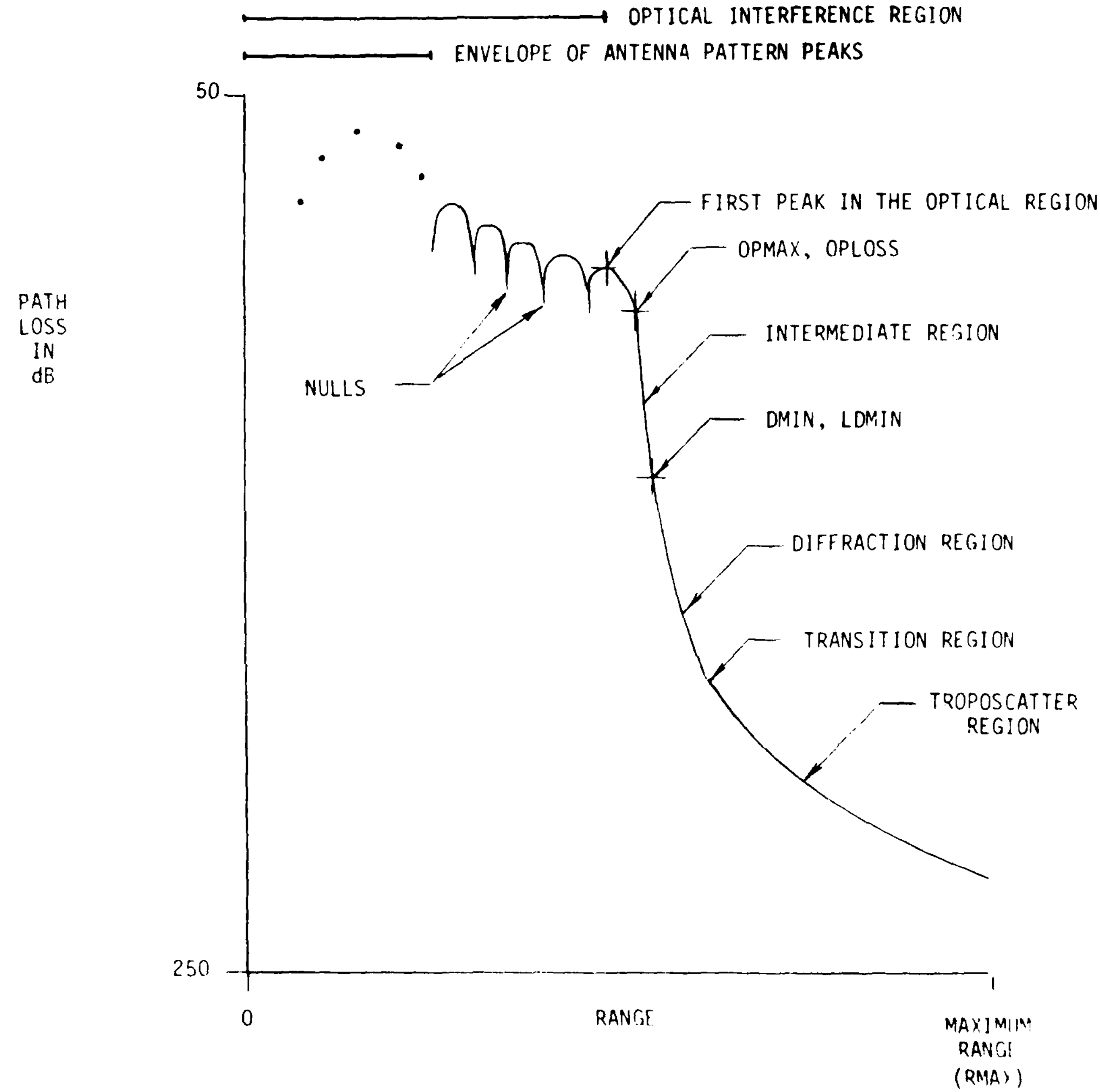


FIGURE 3.4.9-3 REGIONS OF THE LOSS PLOT

The iterative process for plotting OPLOSS is presented in the following algorithm. Refer to Figure 3.4.9-4.

Step 1. Rnow is set to OPMAX. N is set to zero. Set the integer number of increments in peak-to-null, N_x, to zero.

$$D1 = \frac{(\Psi^2+2QHt)^{1/2} - \Psi}{Q} \times 10^{-3}$$

$$D2 = \frac{(\Psi^2+2QHr)^{1/2} - \Psi}{Q} \times 10^{-3}$$

Step 2. If no trapping layer is present go to step 6.

Step 3. Initialize value of θNEXT

$\theta NEXT = -2\pi$

Step 4. $\theta NEXT = \theta NEXT + 2\pi$

Reference the Path Length Difference Subfunction to find the range (Rnext) where the phase difference between the direct and sea-reflected path is equal to θnext.

Step 5. Rnow is set to Rnext

$$\Psi = \frac{Htp \times 10^{-3}}{D1}$$

where Htp is an output of the Reflection Point and Total Phase Difference Subfunction.

N = 1

Go to Step 8.

Step 6. $\theta NEXT = -\frac{\pi}{2}$.

Reference the Path Length Difference Subfunction. If OPMAX $\geq$ Rnext go to Step 7, otherwise set OPMAX equal to Rnext. This operation ensures that OPMAX will be the greater range corresponding to one of the two conditions which define the limits of the optical region: (1) one-quarter wave length limit or (2) grazing angle limit. (θNEXT = $-\pi/2$ is the one-quarter wave length limit.)

$$\psi = \frac{Htp \times 10^{-3}}{D1}$$

$$OPLD = -\frac{\pi}{2}$$

Go to Step 8

Step 7. D1 = DSAVE

D = OPMAX

Reference the Reflection Point and Total Phase Difference Subfunction (3.4.9.10).

Set Opld = θ

Step 8. $\gamma = \frac{D1}{Ae}$

$$Afac1 = \frac{D1 \sin(\frac{\pi}{2} - \psi - \gamma)}{K}$$

$$Afac2 = \frac{D2 \sin(\frac{\pi}{2} - \psi - D2/Ae)}{K}$$

$$\eta = \tan^{-1}\left[\frac{Afac1 \sin(\pi-2\psi)}{Afac2 - Afac1 \cos(\pi-2\psi)}\right]$$

$$\chi = \psi - \eta - \gamma$$

If α < Ttrap go to Step 4.

Step 9. Set Sp to sin ψ and angle to α, then reference the Antenna Pattern Subfunction (3.4.9.8).

Step 10. Patd = Patfac

where Patfac = output of Antenna Pattern Subfunction.

$\beta = \gamma + \psi$

Reference the Antenna Pattern Subfunction to obtain Patfac for the reflected ray

Step 11. $\text{Divfac} = \left(1 + \frac{\gamma^2}{Sp} \right)^{-1/2}$

Reference the Surface Roughness Subfunction (3.4.9.11).

Dr = (Divfac) (Patfac) (Ruf)

where Ruf = output of the Surface Roughness Subfunction.

If this is the first time through the algorithm, go to Step 12.

Otherwise set

Opld = θNEXT

OPMAX = Rnext

Step 12. OPLOSS = Fsterm + 8.686 ln (OPMAX)

- 4.343 ln [Patd^2 + Dr^2 + 2(Patd)(Dr)cos(Opld)

Step 13. Reference the Plot XY Subfunction (3.4.9.18) to plot the point for OPLOSS.

Step 14. Rnow = OPMAX

R = Rnow

Rsave = 2R

If this is not the first time through the algorithm go to Step 16.

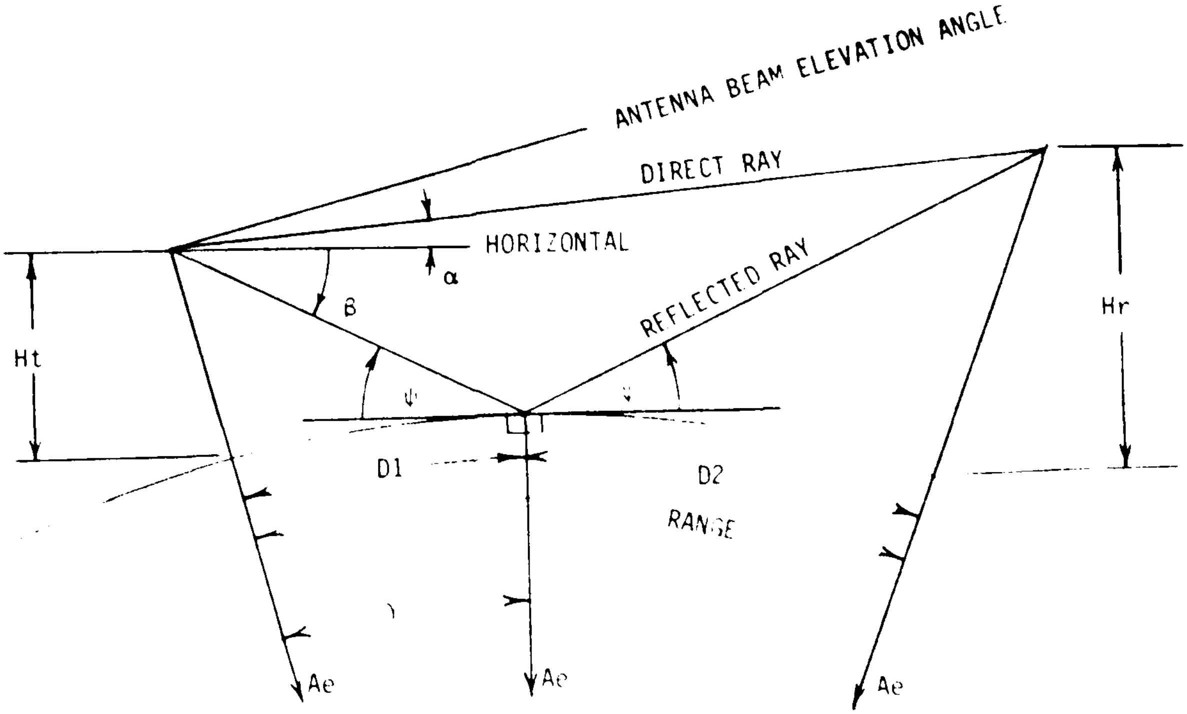


FIGURE 3.4.9-4

GEOMETRICAL RELATIONSHIPS

Step 15. Set N to zero.

θNEXT = 0

Go to Step 17.

Step 16. θNEXT = θNEXT + π

Step 17. Reference the Path Length Difference Subfunction (3.4.9.9).

Step 18. $\Delta R = \frac{Rnow - Rnext}{8}$

D1 = DSAVE

If $\Delta R >$ Rmin go to Step 20 (where Rmin = minimum range of the X-axis).

Step 19. $\Delta R = 2\Delta R$

Nx = 4

Go to Step 21.

Step 20. Nx = 8

The next series of steps in the procedure is an iterative process to plot the null pattern.

Step 21. Repeat through Step 29 Nx times.

Step 22. If this is not the last iteration go to Step 23.

R = Rnext

Opld = θnext

D1 = D1save

D2 = D2save

Htp = Htpsave

Go to Step 24.

Step 23. $R = R - \Delta R$

$D = R$

Reference the Reflection Point and Total Phase Difference Subfunction.

$Opld = 0$

Step 24. $\psi = \dfrac{Htp \times 10^{-3}}{D1}$

$\gamma = \dfrac{D1}{Ae}$

$\beta = \gamma + \psi$

$$Afac1 = \frac{D1 \sin\left(\frac{\pi}{2} - \psi - \gamma\right)}{K}$$

$$Afac2 = \frac{D2 \sin\left(\frac{\pi}{2} - \psi - \frac{D2}{Ae}\right)}{K}$$

$$\eta = \tan^{-1}\left[\frac{Afac1 \sin(\pi - 2\psi)}{Afac2 - Afac1 \cos(\pi - 2\psi)}\right]$$

$\iota = [illegible] - \eta - [illegible]$

$Sp = \sin [illegible]$

$Angle = \iota$

Reference the Antenna Pattern Subfunction.

Step 25. $Patd = Patfac$

$Angle = \beta$

Reference the Antenna Pattern Subfunction.

Reference the Surface Roughness Subfunction.

Step 26. $$Divfac = \left(1 + \frac{\gamma}{Sp}^{2}\right)^{-1}$$

$Dr = (Divfac)\ (Patfac)\ (Ruf)$

$Ffac = Patd^2 + Dr^2 + 2\ (Dr)(Patd)\cos(Opld)$

$Lossfac = Fsterm + 8.686 \ln (R)$

Step 27. If $N \neq 1$ or if this is not the last time through the null pattern iteration, go to Step 28.

If Ffac > 1×10^{-7} go to Step 28.

Loss = Losfac + 70.

Go to Step 29.

Step 28. Loss = Losfac - 4.343 ln (Ffac)

Step 29. If Nx = 1, Reference the Plot XY Subfunction to plot the null.

Step 30. If $\alpha > \alpha_{max}$ and N = 0 go to Step 35.

Rnow = R.

If N=0 go to Step 31.

Set N to zero. Go to Step 16.

The following portion of the algorithm checks to see if only the envelope of the optical maxima should be plotted. The envelope is plotted as a single point at the range of the optical maxima when the null spacing becomes less than Δx, where $\Delta x = \frac{Rmax}{50}$.

Step 31. If Nx = 1 go to Step 33.

If Rsave - R < Δx go to Step 32.

Rsave = R

N = 1

Go to Step 16.

Step 32. Nx = 1 (Note: when Nx = 1, only the values of optical region peaks are plotted.)

Step 33. $\theta NEXT = \theta NEXT + 2\pi$

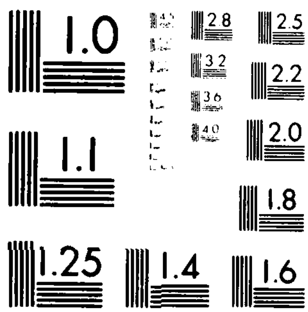
Reference the Path Length Difference Subfunction.

Step 34. If Rnext < Rmin go to Step 35

Otherwise go to Step 21.

AD-A092 297 MEGATEK CORP SAN DIEGO CA F/6 20/14
INTEGRATED REFRACTIVE EFFECTS PREDICTION SYSTEM (IREPS): PROGRA--ETC(U)
JUL 80 H V HITNEY, E W PASAHOW, M E O'BRIAN N00123-78-C-0043
UNCLASSIFIED R2018-059-IF-2 NOSC-TD-365 NL

AD
A092297



MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

Step 35. Reference the Plot XY Subfunction.

$L = 1$

$x = DMIN$

If $x \leq Rmax$ go to Step 37.

Step 36. Reference the Diffraction/Troposcatter Loss Subfunction (3.4.9.6)

$LDMIN = Diff$

$$Loss = OPLOSS - \frac{(OPLOSS - LDMIN)\ (Rmax-OPMAX)}{DMIN - OPMAX}$$

Reference the Plot XY Subfunction. Transfer control to the Terminate Loss Subfunction (3.4.9.17).

Step 37. Reference the Diffraction/Troposcatter Loss Subfunction.

$LDMIN = Diff$

Reference the Plot XY Subfunction.

Step 38. $x = x + \Delta x$

If $x \leq Rmax$ go to Step 39.

Reference the Diffraction/Troposcatter Loss Subfunction.

$Loss = Diff$

Reference Plot XY Subfunction. Transfer control to the Terminate Loss Subfunction.

Step 39. Reference the Diffraction/Troposcatter Loss Subfunction.

$Loss = Diff$

Reference the Plot XY Subfunction. Go to Step 38.

3.4.9.5.3 Outputs

Plot of the loss pattern for surface platforms.

3.4.9.6 Diffraction/Troposcatter Loss Subfunction

3.4.9.6.1 Inputs

a. X-axis range value

b. Flag indicating whether the region is dominated by tropospheric scattering

3.4.9.6.2 Processing

This subfunction is called by the Loss For Surface Systems Subfunction. This routine computes the loss for the diffraction and troposcatter regions. The following algorithm is used.

Step 1. Tlr = 4.343 ln(x)

Tloss = x Tfac + 2 Tlr + Trofac

where Tloss = troposcatter loss in dB
Trofac = parameter calculated in the Diffraction and Troposcatter Field Constants Subfunction
x = range in km

Step 2. If tropospheric scattering does not dominate (A set flag indicates that the region is already known to be dominated by tropospheric scattering.)
Diff = Difac + Tlr + (x)(Attenuation)
Compare with the tropospheric scatter loss
Dif = Diff - Tloss, and
if Dif < -18 then terminate the algorithm.
If Dif > 18 go to Step 4.

Step 3. Otherwise compute the loss in the transition region.
$$\text{Diff} = \text{Diff} - 4.343 \ln\left[1 + \exp\left(\frac{\text{Dif}}{4.343}\right)\right]$$
Terminate the algorithm.

Step 4. Tflag = 1, because tropospheric loss dominates by at least 18 dB

Step 5. Diff = Tloss.

Terminate the algorithm.

Control is returned to the calling subfunction.

3.4.9.6.3 Outputs

a. Loss in the troposcatter region.

b. Loss in the diffraction region.

c. Flag indicating whether tropospheric scattering loss dominates.

3.4.9.7 Surface Trace Subfunction

3.4.9.7.1 Inputs

a. Initial ray launch angle

b. Ht and Hr

c. Array containing the heights at which each layer starts (Hmrs)

d. Array containing 10^{-3} times the change in modified refractivity with height for each layer (Dmdh)

3.4.9.7.2 Processing

This subfunction is called by the Loss Plot Subfunction. Ray tracing is accomplished using the small angle approximation for Snell's Law (see NOSC TN 669).

The following algorithm is used in ray tracing.

Step 1. Initialize variables

R = 0

H = Ht

$AO = \alpha$

Where

R = ground range covered by the ray trace

H = height

AO = initial ray launch angle

Step 2. If AO > 0 then go to Step 3

$$R = -\frac{2AO}{Dmdh(1)}$$

where

Dmdh(1) = first item in the array

Step 3. Set AO = -AO

The following procedure through Step 6 performs the raytrace to the top of layer j. If there is only 1 item in the Hmrs array, go to Step 7.

Step 4. Set counter j to 1

Step 5. If Hmrs (j+1) > Hr go to Step 8.

Step 6. $\Delta M = [Hmrs(j+1)-H]\ Dmdh(j) \times 10^{-3}$

$Alt = (AO^2 + 2\Delta M)^{1/2}$

$$\Delta R = \frac{Alt-AO}{Dmdh(j)}$$

$R = R + \Delta R$

$H = Hmrs(j+1)$

$AO = Alt$

Have all items in the Hmrs array been processed? if yes, go to Step 8. If no, increment j go to Step 5.

Step 7. j = 1

Step 8. The remaining steps in the algorithm perform the raytrace from the top of layer j-1 to Hr. (In a single layer atmosphere the trace is performed to Hr.) If Hr = H then go to Step 10.

Step 9. $\Delta M = (Hr-H)Dmdh(j) \times 10^{-3}$

$$Alt = (AO^2 + 2\Delta M)^{1/2}$$

$$\Delta R = \frac{Alt-AO}{Dmdh(j)}$$

Terminate the algorithm.

Step 10. Set R to the greater of R or Delx. Terminate the algorithm. Control is returned to the calling subfunction.

3.4.9.7.3 Outputs

The total ground range covered by the ray trace.

3.4.9.8 Antenna Pattern Subfunction

3.4.9.8.1 Inputs

a. Type of antenna pattern as listed in Table 3.4.9-2.

b. Elevation angle of the direct ray.

c. Elevation angle of antenna.

d. Elevation angle of the reflected ray (surface systems only).

3.4.9.8.2 Processing

This subfunction is called by the Loss for Surface Systems Subfunction. This routine is used for both air and surface system antenna patterns. The following algorithm is used for all antenna types. (See NOSC TN 669.)

Step 1. Set the Pattern Function (Patfac) to 1.

Step 2. For omnidirectional antennas, terminate the algorithm.

Step 3. If the antenna is a height-finder, set the elevation angle of the antenna to the elevation angle of the direct ray (α).

Step 4. Locate the ray with respect to the center of the antenna. Apat = Elevation angle of the antenna - angle of the ray being traced

Step 5. If the antenna type is cosecant-squared, go to step 7.

Step 6. If $|Apat| < 1 \times 10^{-6}$ terminate the algorithm. Otherwise, find the antenna pattern function for a $\frac{\sin x}{x}$ or height-finder antenna.

$$Patfac = \frac{\sin [Antfac\ (\sin(Apat))]}{Antfac\ [\sin(Apat)]}$$

Terminate the algorithm.

Step 7. If $|Apat| \leq \frac{BW}{2}$ then terminate the algorithm.

where BW = 1.745×10^{-2} times vertical beamwidth of the antenna in radians.

Step 8. $Patfac = \frac{Antfac}{\sin\ (|Antfac|)}$

Terminate the algorithm.

Control is returned to the calling subfunction.

3.4.9.8.3 Outputs

Antenna pattern factor for a given ray angle input.

3.4.9.9 Path Length Difference Subfunction

3.4.9.9.1 Inputs

a. Range (Rnow)

b. Last known reflection point (D1)

c. Given multiple of the wave length (θNEXT)

d. Distance to the radio horizon (Horizon)

3.4.9.9.2 Processing

This subfunction is called by the Loss For Surface Systems Subfunction. This subfunction determines the range at which the optical path length difference equals a given number of odd multiples of wavelength (that is the range of a particular null). Newton's method is used. (See NELC TN 3037.) This subfunction is referenced by the Loss for Surface Systems Subfunction.

Step 1. Initialize variables

Dsave = D1

where D1 = Last known reflection point.

D = Rnow

Step 2. Repeat through Step 6 ten times. Reference the Reflection Point and Total Phase Difference Subfunction.

D = D + 0.100

Reference the Reflection Point and Total Phase Difference Subfunction

Step 3. $F1 = \theta$

$$Fp = \frac{F1-F}{0.100}$$

$$Dd = \frac{F- ONEXT}{Fp}$$

If Dd > -D go to Step 5

Step 4. $D = \frac{D}{2}$ go to Step 7

Step 5. If Horizon > D + Dd go to Step 6

$$D = \frac{Horizon + D}{2}$$

Go to Step 7.

Step 6. D = D + Dd

If |Dd| < 0.100 go to Step 8

Step 7. Increment the count. If not 10, go to Step 2.

Step 8. Rnext = D

D1save = D1

D2save = D2

Htpsave = Htp

Step 9. Terminate the algorithm

Control is returned to the calling subfunction.

3.4.9.9.3 Outputs

Range at which optical path difference equals a given number of odd multiples of the wavelength.

3.4.9.10 Reflection Point and Total Phase Difference Subfunction

3.4.9.10.1 Inputs

a. Last known reflection point (D1)

b. Range (D)

c. Frequency (f)

d. Effective earth radius (Ae)

3.4.9.10.2 Processing

This subfunction is called by the Loss For Surface Systems Subfunction. This subfunction computes the total optical path difference (including phase lag on reflection) using a cubic equation which determines the current reflection point starting with the last known reflection point. (See NELC TN 3037.) A Newton's iteration method is used for finding the solution.

Step 1. Initialize variables

$$T = -1.5D$$

$$V = \frac{D^2}{2} - Ae\,(Hr + Ht) \times 10^{-3}$$

Step 2. Repeat through Step 4 ten times

$$\Delta D = \frac{D1^3 + (T)(D1^2) + (V)(D1) + W}{3D1^2 + 2(D1)(T) + V}$$

$$D1 = D1 - \Delta D$$

where $W = D\,(Ae)(Ht) \times 10^{-3}$

Step 3. If $|\Delta D| < 0.100$, go to Step 5.

Step 4. Increment counter, if not ten go to Step 2.

Step 5. $D2 = D - D1$

$$Htp = Ht - \frac{D1^2}{2Ae \times 10^{-3}}$$

$$Hrp = Hr - \frac{D2^2}{2Ae \times 10^{-3}}$$

$$\theta = \frac{4.193\ f(Htp)(Hrp) \times 10^{-5}}{D} - \pi$$

Step 6. Terminate the algorithm

Control is returned to the calling subfunction.

3.4.9.10.3 Outputs

a. Reflection point range for a given total range

b. Total phase difference

3.4.9.11 Surface Roughness Subfunction

3.4.9.11.1 Inputs

a. Frequency

b. Rms ocean wave height ($\bar{h}$)

c. Grazing angle (ψ)

3.4.9.11.2 Processing

This subfunction is called by the Loss For Surface Systems Subfunction. This subfunction computes the surface roughness factor. (See NOSC TN 669.)

Step 1. If $-2(0.2094f\bar{h} \sin \psi) < -0.95555$, go to Step 3.

Step 2. Roughness factor = $\exp[-2(0.2094f\bar{h} \sin \psi)]$
Terminate the algorithm.

Step 3. If $0.2094f\bar{h}\psi > 0.26$, go to Step 4
Roughness factor = $0.5018913 - [0.2090248 - (\frac{\psi}{2} - 0.55189)^2]^{1/2}$

Terminate the algorithm.

Step 4. Roughness factor = 0.15.
Terminate the algorithm.

Control is returned to the calling subfunction.

3.4.9.11.3 Outputs

Roughness factor value (Ruf).

3.4.9.12 Loss For Airborne Systems Subfunction

3.4.9.12.1 Inputs

a. Ht and Hr

b. Maximum range of plot

c. M Unit array

d. Antenna maximum elevation angle (α_{max})

e. Array containing the height at which each layer starts (Hmrs)

f. Array containing 10^{-3} times the change in modified refractivity with height for each layer (Dmdh).

3.4.9.12.2 Processing

This subfunction is called by the Plot and Label Axes Subfunction. This subfunction computes the loss for airborne systems. If the transmitting antenna is in a duct, two critical angles are determined: α_d and α_c. The first, α_d, is the angle above which all rays are not trapped and are monotonically upgoing. The second, α_c, is the angle below which all rays are not trapped and are downgoing, but may be reflected from the surface. In the airborne loss diagram, the height interval of the duct is assumed to be illuminated to twice the free space range for an emitter in the duct. Downgoing rays are traced only to the surface; the reflected rays are not traced. (See NOSC TN 669.) All rays traced are within the main beam of the antenna. Side lobe rays are not included.

The critical angles are found as follows:

$$\alpha_d = [2(MT - MTmin)]^{1/2} \times 10^{-3} \text{ radians}$$

$$\alpha_c = -\alpha_d$$

where MTmin = minimum M-value of the profile above Ht

Mt = M-value at Ht

In this subfunction, angular conversion factors are set up, and arrays used for the ray trace are initialized first. Next a determination is made as to whether or not the transmitter is in a duct.

If both Ht and Hr are in a duct, the free space loss -6 dB is plotted to twice the free space range of the EM system by referencing the Airborne Ray Trace Subfunction. Then control is transferred to the Loss Array Subfunction (3.4.9.16).

If Ht is in a duct and Hr is not, or if Ht is not in a duct then, the starting and ending range(s) of any "holes" caused by trapping or super-refractive layers is (are) located. (Only layers below Ht can cause radar holes if the transmitter is not in a duct.) If there are holes, they are "filled" from the start to end for those ranges with a free-space loss of +30 dB. All layers below Ht are then examined for holes.

Next, the launch angle, α, is found. The first α is normally the most negative angle within the main beam of the antenna. If α is greater than α_{max} the array of loss values to be plotted is set up and control is given to the Terminate Loss Plot Subfunction. Otherwise, the Antenna Pattern and Airborne Ray Trace Subfunctions are each referenced in turn. The next value for α is then obtained and the comparison with α_{max}, as described above, is repeated.

3.4.9.12.3 Outputs

Loss array values for airborne systems.

3.4.9.13 Airborne Ray Trace Subfunction

3.4.9.13.1 Inputs

a. Launch angle of the ray

b. Ht and Hr

c. Top and bottom heights of the duct

d. Launch angle below which no rays are trapped in the duct (α_c)

e. Launch angle above which no rays are trapped in the duct (α_d)

f. Non-range dependent loss in the diffraction region (Fsterm)

3.4.9.13.2 Processing

This subfunction is called by the Loss For Airborne Systems Subfunction. This subfunction plots the path loss for airborne system.

Ray tracing is accomplished using the small angle approximation for Snell's Law (see NOSC TN 669). Three situations characterize the ray tracing:

a. Case I. The ray trace possibilities for rays that are not trapped and meet the conditions Ht $\geq$ Hr and $\alpha \leq 0^0$ where α = launch angle of ray at the antenna are described below. A downgoing ray may intersect height Hr twice. For example if $\alpha > \alpha_r$, Hr $> H_1$, and R $< R_{MAX}$ as shown in Figure 3.4.9-5 there is only one intersection for $\alpha < \alpha_r$.

b. Case II. If Ht < Hr and $\alpha > \alpha_r$ there is only one range, loss solution for these rays. It occurs at positive ray angles for both α_1 and α_2 and H_r = H3 as shown in Figure 3.4.9-5.

c. Case III. If Ht > Hr no solution may be possible, if all the

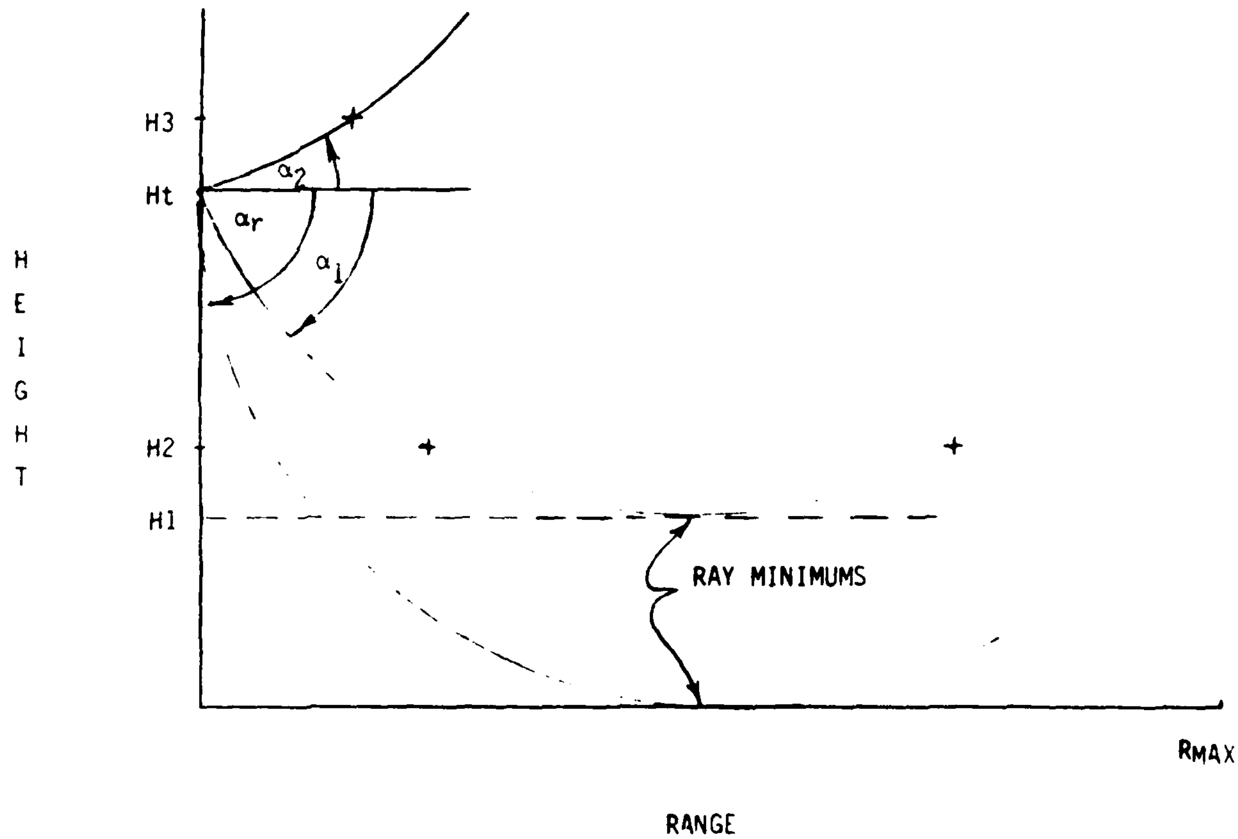


FIGURE 3.4.9-5

RAYTRACE GEOMETRIES

angles within the main beam of the antenna are too high to intersect Hr. This is an unusual case, but it may be possible for antennas with narrow beamwidths when pointed upward. This would be the case if α_1 was equal to the most negative angle within the main beam of the antenna and $H_r < H_1$.

Step 1. Initialize variables
AO = α
Ht = Antenna Height
Rng = 0 = Rx

Step 2. If AO > α_d, then reference the Upgoing Subfunction (3.4.9.15).

Step 3. If AO < α_c, then reference the Downgoing Subfunction (3.4.9.14).

Step 4. If α = 0 and α_d = 0, then reference the Upgoing Subfunction.

Step 5. If Hr $\leq$ top height of duct and Hr $\geq$ bottom height of duct, go to Step 7.

Step 6. $\alpha = \alpha_d$, terminate the algorithm.

Step 7. Both Ht and Hr are in the duct.
Loss = Fsterm - 6.02 + 8.686 ln(Rmin)
Reference the Plot XY Subfunction

Step 8. Plot the next 19 points in increments of Rmin.
Loss = Fsterm - 6.02 + 8.686 ln (Rx)
Where Rx is incremented by Rmin on each iteration.
Reference the Plot XY Subfunction.

Step 9. Transfer control to the Terminate Loss Plot Subfunction.

3.4.9.13.3 Outputs

Loss plot for airborne systems.

3.4.9.14 Downgoing Subfunction

3.4.9.14.1 Inputs

a. Hr and Ht

b. Array containing the height at which each layer starts (Hmrs)

c. Maximum range

d. Layer index counter

e. Loss array

f. Array containing 2×10^{-6} times the change in refractivity of each layer (Twodm)

g. Angle of the tangent ray (α_r)

h. Launch angle of the ray

i. Array containing 10^{-3} times the change in refractivity of each layer (Dmdh)

3.4.9.14.2 Processing

This subfunction is called by the Airborne Ray Trace Subfunction. This subfunction performs a ray trace for non-trapped angles with negative launch angles from air platforms. Steps 1 through 7 do the ray trace for layers where the value in the Hmrs array is greater than Hr. Steps 8 through 11 do the trace to height Hr and calculate the loss.

Step 1. If Ht > Hr go to Step 3.

Step 2. If Ht is in the first layer, trace the ray to minimum height, double the range, set height equal to Ht, and A0 = -A0. Then transfer control to the Upgoing Subfunction.

Step 3. If the layer index counter (i) is 1, go to Step 8.

Step 4. Decrement the layer index counter. If the layer index counter is 1, go to Step 8. Check to see if Hr is in layer i. If Hmrs(i) < Hr go to Step 8.

where Hmrs(i) = the ith item in array Hmrs

Step 5. $Anext = -Twodm(i) + A0^2$

If Anext < 0 then terminate the algorithm. (The ray reaches minimum before the height equals Hrms(i)).

Step 6. $A1 = -(Anext)^{1/2}$

$$Rx = Rx + \frac{A1 - A0}{Dmdh(i)}$$

If Rx > Rmax terminate the algorithm.

Step 7. H = Hmrs(i)

A0 = A1

Go to Step 4.

Step 8. $\Delta H = Hr - Hmrs(i+1)$

$Anext = A0^2 + (\Delta H)Dmdh(i) \times 10^{-3}$

If Anext < 0 terminate the algorithm because the ray does not reach height Hr.

Step 9. $A1 = -(Anext)^{1/2}$

$$Rx = \frac{A1-A0}{Dmdh(i)} + Rx$$

If $Rx > Rmax$ terminate the algorithm.

If $Rx < Rmin$ go to Step 12.

Step 10. Compute loss array index.

$Ir = INT[(Rx)(Rnib)]$

where INT = integer function

Rnib = smallest range interval that can be plotted

$$Loss = Fsterm + 8.686 \ln\left(\frac{Rx}{Patd} \right)$$

If Loss < 50 or Loss > 250 go to Step 12.

Step 11. $Losint = INT [(Loss-50)]$

If Loss(Ir) = 0 or Los(Ir) > Losint then set Los(Ir) = Losint

where Los(Ir) = the Ir item in the Loss array.

Step 12. If $\alpha < \alpha r$ terminate the algorithm.

Otherwise, continue the trace to the second intercept with height Hr.

Step 13. A0 = A1

If i = 1, go to Step 20.

Step 14. Find the trace to Hmrs(i) from Hr.

$\Delta H = Hmrs(i) - Hr$

$Anext = A0^2 + (\Delta H)Dmdh(i) \times 10^{-3}$.

Step 15. Test to see if ray reaches a minimum height greater than Hmrs(i).

If Anext < 0 go to Step 20.

Step 16. $A1 = -(Anext)^{1/2}$

$$Rx = Rx + \frac{A1-A0}{Dmdh(i)}$$

If Rx > Rmax terminate the algorithm

Step 17. H = Hmrs(i)

A0 = A1

Step 18. Decrement layer index counter, i.

If i is 1 go to Step 20.

Step 19. $Anext = -Twodm(i) + A0^2$.

Go to step 15.

Step 20. Trace the ray to minimum height.

$$\Delta H = \frac{-500\ A0^2}{Dmdh(i)}$$

$H1 = Hmrs\ (i+1) + \Delta H$

If H1 > Hr terminate the algorithm.

Step 21. $$Rx = Rx - \frac{A0}{Dmdh(i)}$$

If Rx < Rmax terminate the algorithm.

If Hr > Ht go to Step 23.

Step 22. A0 = 0

H = H1

Istart = i

Go to Step 2 of the Upgoing Subfunction.

Step 23. Rx = 2Rx

If Rx > Rmax terminate the algorithm.

Step 24. AO = $-\alpha$

H = Ht

Transfer control to Step 1 of the Upgoing Subfunction.

3.4.9.14.3 Outputs

a. Range at which the ray intercepts Hr.

b. The loss array value at the range.

3.4.9.15 Upgoing Subfunction

3.4.9.15.1 Inputs

a. Layer index counter

b. Array containing height at which each layer starts (Hmrs)

c. Array containing 10^{-3} times the change in modified refractivity with height for each layer (Dmdh)

d. Array containing 2×10^{-6} times the change in refractivity of each layer (Twodm)

e. Hr and Ht

f. Maximum range

g. Loss array

h. Launch angle of the ray

3.4.9.15.2 Processing

This subfunction is called by the Airborne Ray Trace Subfunction. This subfunction performs a ray trace for non-trapped rays with positive launch angles. Upon termination of the algorithm control returns to the calling subfunction.

Step 1. Istart = Source index value

Step 2. If there is only one layer, go to Step 6.

Step 3. Trace the ray in the current layer. For all layers from i = Istart through the remainder of the Hmrs array repeat Step 4.

Step 4. If $Hmrs(i+1) \geq Hr$ go to Step 6.

$$A1 = [A0^2 + Twodm(i)]^{1/2}$$

$$Rx = Rx + \frac{A1 - A0}{Dmdh(i)}$$

If Rx > Rmax terminate the algorithm.

A0 = A1

H = Hmrs(i+1)

Step 5. Trace the ray path for a single-layer atmosphere or the top of a multilayer atmosphere. Set i to index of top layer.

Step 6. $\Delta M = (Hr-H)Dmdh(i) \times 10^{-3}$

$$A1 = (A0^2 + 2\Delta M)^{1/2}$$

$$Rx = Rx + \frac{A1 - A0}{Dmdh(i)}$$

If Rx > Rmax then terminate the algorithm.

If Rx < Rmin then terminate the algorithm.

Step 7. $Ir = INT [\frac{Rx}{Rnib}]$

where INT = integer function

Rnib = smallest range interval that can be plotted

$Loss = Fsterm + 8.686 \ln (\frac{Rx}{Patd})$

If Loss < 50 or Loss > 250 terminate the algorithm.

Losint = INT [(Loss-50)]

Step 8. If Los (Ir) = 0 or Los(Ir) > Losint then Los(Ir) = Losint.

where Los = array of Loss values to be plotted.

Terminate the algorithm.

Return control to the calling subfunction.

3.4.9.15.3 Outputs

a. Range at which the ray intercepts Hr

b. The Loss Array value at that range

3.4.9.16 Loss Array Subfunction

3.4.9.16.1 Inputs

Loss Array

3.4.9.16.2 Processing

This subfunction is called by the Loss For Airborne Systems Subfunction. This subfunction examines each of the entries in the Loss Array. If the entry is zero, no action is taken. Otherwise, if this is the first point to be drawn, the position of the plot pointer is moved to that coordinate and the plotter is switched to the draw mode. When the next non-zero entry in the loss array is found a line is drawn from the present position to those coordinates. This action is repeated for all points in the Loss Array. If any loss value exceeds the scale of the plot, a warning message is displayed. Control is then transferred to the Terminate Loss Plot Subfunction.

3.4.9.16.3 Outputs

Loss Plot

3.4.9.17 Terminate Loss Plot Subfunction

3.4.9.17.1 Inputs

a. Classification flag setting

b. Name of plot

c. Location

e. Array of data to be plotted

f. Free space range

3.4.9.17.2 Processing

This subfunction is called by the Loss Array and the Loss For Surface Systems Subfunctions. This subfunction plots the loss display which is shown in Figure 3.4.9-1. The security classification header is printed at the top of the page followed by the title, "Loss Display" and the name. The location and date/time lines are then printed. Next the actual data is plotted on the axes which were previously set-up. The legend, "Dashed line indicates detection, communication, or intercept threshold", is printed followed by the free space range, frequency, transmitter or radar height, and receiver or target height. Finally the security classification is printed at the bottom of the display.

If the Auto-Mode array has commands entered in it, the next command is executed (see 3.4.1). When all Auto-Mode commands have been processed, control is transferred to the Options Function (3.4.10).

3.4.9.17.3 Outputs

Loss display plot with headings

3.4.9.18 Plot XY Subfunction

3.4.9.18.1 Inputs

a. Coordinates of the point

b. Move/draw flag

3.4.9.18.2 Processing

This subfunction is called by the Air Trace and Loss For Surface Systems Subfunctions. If the move/draw flag is clear, the plot position is moved to the input coordinates. If the flag is set, a line is drawn from the present position to the input coordinates. Control is returned to the calling subfunction.

3.4.9.18.3 Outputs

a. Change in the plot position

b. A line is drawn (if the move/draw flag is set)

3.4.9.19 Set-Up Subfunction

3.4.9.19.1 Inputs

None

3.4.9.19.2 Processing

This subfunction is called by the Loss Entry Subfunction. The Set-Up Subfunction is used to initialize the default values of all variables and arrays. The lengths of character variables and dimensions for all arrays are established. All files are assigned symbolic names. Control is returned to the calling subfunction.

3.4.9.19.3 Outputs

None

3.4.9.20 Error Subfunction

3.4.9.20.1 Inputs

None

3.4.9.20.2 Processing

Prints a message to the operator that an error has occurred. Control is passed back to the calling subfunction.

3.4.9.20.3 Outputs

Error message to operator

3.4.10 Options Function

This function displays a menu which allows the operator to select any other IREPS function. The Options Function is referenced at the completion of the other functions or in response to the operator entering the "Options" command.

3.4.10.1 Option List Subfunction

3.4.10.1.1 Inputs

None.

3.4.10.1.2 Processing

The operator is presented with a display of the selections available as listed in Table 3.4.10-1. These items are arranged in a menu fashion and the operator selects the function by its number.

Table 3.4.10-1. IREPS Options Menu

Item Number	Function
1	Summary
2	Environmental Data List
3	Cover
4	Loss
5	Automatic
6	Edit
7	Input
8	ESM

9	RAOB
10	Surface Search
11	End IREPS

Pressing the "Back-Up" key at this point transfers control to the beginning of the Input Function. The same transfer occurs if the operator selects the menu entry for Input (item 7). A summary of the transfer of control for each item is given below.

If This Item is Selected	Control is Transferred to
1	Summary Function
2	List Function
3	Cover Function
4	Loss Function
5	Auto-Mode Function
6	Edit Function
7	Input Function
8	ESM Function
9	RAOB Function
10	Surface Search Function
11	End IREPS Subfunction (See 3.4.10.4)

Selection of an item number outside the range causes the Error Subfunction to be referenced. Then control is returned to the point where the error occurred and another operator input is requested.

3.4.10.1.3 Outputs

Menu Listing IREPS options

3.4.10.2 Set-Up Subfunction

3.4.10.2.1 Inputs

None

3.4.10.2.2 Processing

This subfunction is called by the Option List Subfunction. The Set-Up Subfunction is used to initialize the default values of all variables and arrays. The lengths of character variables and dimensions for all arrays are established. All files are assigned symbolic names. Control is returned to the calling subfunction.

3.4.10.2.3 Outputs

None

3.4.10.3 Error Subfunction

3.4.10.3.1 Inputs

None

3.4.10.3.2 Processing

This subfunction is referenced by any other subfunction to display a message to the operator indicating that an invalid or erroneous response has been made in response to a prompt. A mass storage device error also causes a reference to this subfunction.

In case of a mass storage device error, this subfunction causes a fatal error after informing the operator that a malfunction has occurred with the mass storage device. Any diagnostic information available is also displayed to the operator, then the processor is halted.

3.4.10.3.3 Outputs

Message displayed to operator.

3.4.10.4 End IREPS Subfunction

3.4.10.4.1 Inputs

None.

3.4.10.4.2 Processing

This subfunction is called by the Option List Subfunction. This subfunction restores all peripheral equipment to an initialized condition.

3.4.10.4.3 Outputs

Commands to peripheral equipment.

3.4.11 RAOB Function

The RAOB Function produces listings (modeled after the National Weather Service form MF3-31A, B, C and the Military form DOD-WPC 9-31A, B, C) of significant and mandatory levels of the sounding, computes meteorological parameters, plots a "Skew-T, log p" diagram, and generates an encoded WMO Radiosonde Code message. Figure 3.4.11-1 through 3.4.11-3 presents a typical example of the output. The WMO Radiosonde Code message is specified by the Federal Meteorological Handbook No. 4, Radiosonde Code.

3.4.11.1 Station Subfunction

3.4.11.1.1 Inputs

None

3.4.11.1.2 Processing

This subfunction is called by the Options Function. The Set-Up Subfunction is referenced, then the operator is prompted to enter the station identification. (Station identification is a 1 to 18 character ASCII string.) Entry of the "Back-Up" command transfers control to the Input Function (3.4.7). The entry is stored and displayed to the operator.

Next a prompt to enter the release date is displayed. Entry of the "Back-Up" command transfers control to the station identification entry above. An invalid entry causes the Error Subfunction to be referenced followed by another prompt. A valid entry is constrained to these limits.

**** RADIOSONDE LISTING ****

STATION : NAVAL OCEAN SYSTEMS CENTER
LOCATION : 32 42N 117 15W
DATE/TIME: 8 MAY 1980 1128 ZULU

WIND DIRECTION (DEGREES) : 275 RSONDE SERIAL NO : 77-00405
WIND SPEED (KNOTS) : 10 ASCENSION : 001

PRESSURE CONTACT SETTING : 5.2 PRESSURE : 1011.1
BASELINE TEMP ORDINATE : 70.3 BASELINE TEMP : 24.7
BASELINE RH ORDINATE : 76.4 BASELINE RH : 32.0

TIME	PRESS (mb)	TEMPERATURE ORD	(C)	REL. ORD	HUM (%)	DEW PT (C)	DEW PT DEP(C)	HEIGHT (MTRS)
0.0	1011.1	-	14.0	-	67	8.0	6.0	10
*****	1000.0		13.4		69	7.7	5.6	103
3.2	910.0	61.8	7.8	18.7	83	5.1	2.7	890
*****	850.0		2.9		80	-.2	3.1	1448
8.7	798.0	56.0	-1.7	28.0	77	-5.2	3.5	1956
9.1	784.0	54.0	-4.8	12.0	88	-6.5	1.7	2096
9.4	776.0	54.7	-3.7	67.3	49	-12.9	9.2	2177
*****	700.0		-5.4		37	-17.8	12.4	2988
14.9	663.0	53.0	-6.3	76.8	32	-20.4	14.1	3414
16.8	622.0	47.8	-13.7	62.2	55	-20.8	7.1	3906
17.2	603.0	46.9	-15.0	81.7	19	-	30.0	4142
21.5	535.0	42.8	-20.6	69.0	46	-29.2	8.6	5037
24.0	500.0	40.4	-24.4	78.6	25	-38.8	14.4	5534
*****	400.0		-36.3		22	-50.5	14.2	7121
31.7	378.0	28.9	-39.3	80.5	20	-53.5	14.2	7511
37.5	300.0	21.0	-50.9					9055
40.3	276.0	17.2	-57.2					9590

Asterisks in time column indicate internally generated mandatory level

CLOUDS .2CU .4SC
WX BFN

Figure 3.4.11-1. Typical Radiosonde Listing

```
STATION  : NAVAL OCEAN SYSTEMS CENTER
LOCATION :  32 42N  117 15W
DATE/TIME:  8 MAY 1980   1128 ZULU

LIFTING CONDENSATION LEVEL (LCL):
      PRESSURE        : 924.3 mB
      TEMPERATURE     : 6.7 DEGREES C
      HEIGHT          : 2516.2 FEET

CONVECTIVE CONDENSATION LEVEL (CCL):
      PRESSURE        : 889.7 mB
      TEMPERATURE     : 6.2 DEGREES C
      HEIGHT          : 3525.3 FEET
      CONVECTION TEMP: 16.6 DEGREES C

LEVEL OF FREE CONVECTION (LFC):
      PRESSURE        : 848.9 mB
      TEMPERATURE     : 2.8 DEGREES C
      HEIGHT          : 4785.5 FEET

SHOWALTER INDEX       : 3.3


FREEZING LEVEL AT   5796 FEET ( 817 mB)

POSSIBLE CONTRAIL FORMATION:
        24769 TO  29822 FEET

CONTRAIL FORMATION:
        29822 TO  31463 FEET
```

PRESSURE ALTITUDE (FT)	D-VALUE (FT)
1000	-28
2000	-28
3000	-22
4000	-28
5000	-30
6000	-39
7000	-50
8000	-65
9000	-72
10000	-74
11000	-72
12000	-74
13000	-75
14000	-88
15000	-102
16000	-109
17000	-115
18000	-125

Figure 3.4.11-1 (Cont'd) Typical Radiosonde Listing

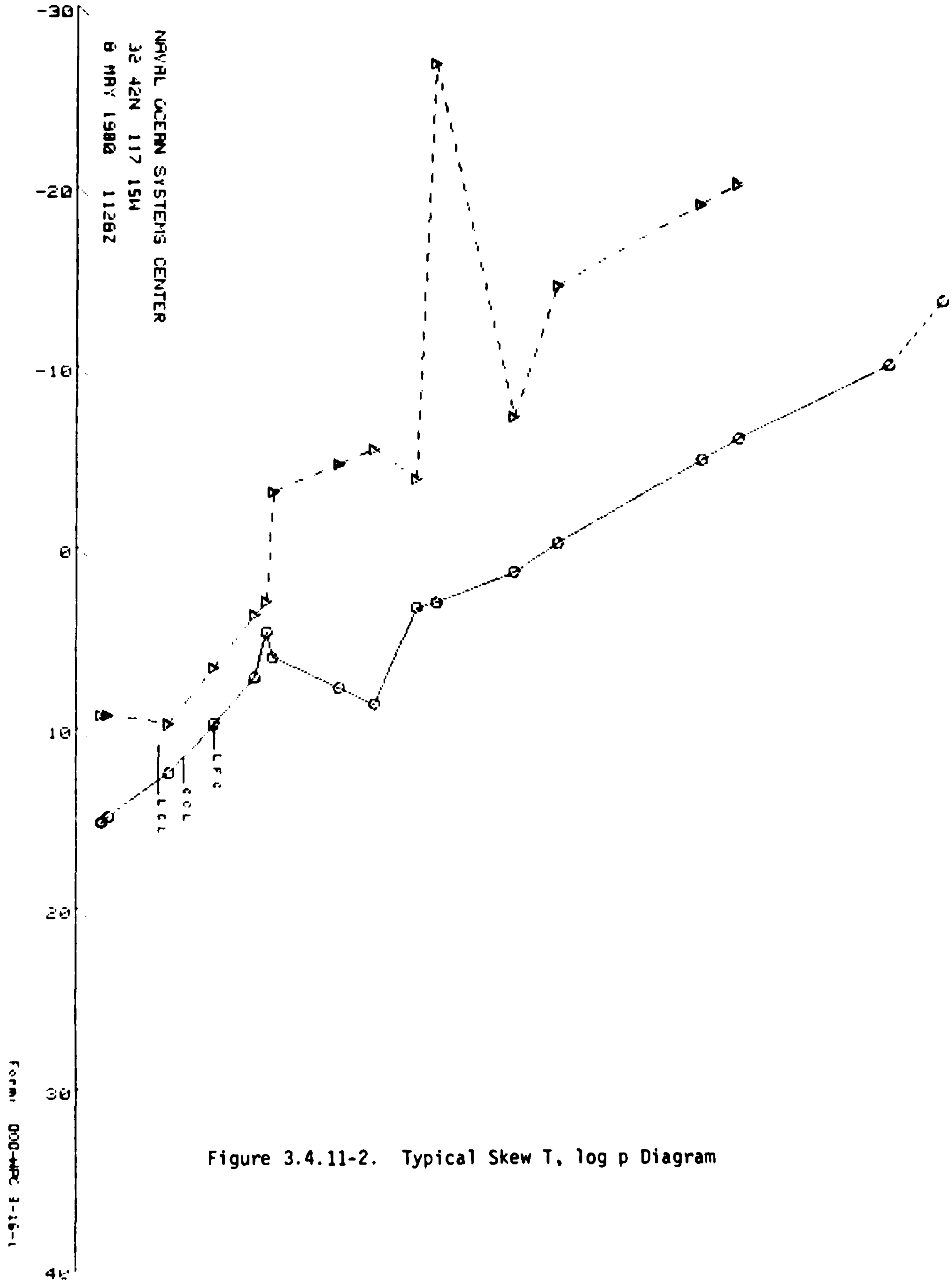


Figure 3.4.11-2. Typical Skew T, log p Diagram

```
WMO CODE PART A

UUAA  5812  99327 71173 12027 99011 14056 27510 00103 13456 85448
02831 70988 05562 50553 24564 40712 36364 30906 509   88999 77999

WMO CODE PART B

UUBB  5812  99327 71173 12027 00011 14056 11910 07827 22798 01734
33784 04917 44776 03759 55663 06364 66622 13757 77603 15180 68535
20759 99500 24564 11378 39364 22300 509   33276 573   51515 10156
```

Figure 3.4.11-3 Typical Encoded WMO Radiosonde Message

1900 < Year < 2000

Month = three character string from Table 3.4.11-1

Day = 28 if month = "FEB" and the year is not leap year

29 if month = "FEB" for leap year

30 if month = "APR", "JUN", "SEP", or "NOV"

31 otherwise

Table 3.4.11-1. Valid Month ASCII Strings

JAN	JUL
FEB	AUG
MAR	SEP
APR	OCT
MAY	NOV
JUN	DEC

A valid entry is stored and displayed to the operator.

The operator is then prompted to enter the release Greenwich mean time (GMT). The default value is zero. Entry of the "Back-Up" command transfers control to the release date entry above. An invalid entry causes the Error Subfunction to be referenced followed by another prompt. The range of valid entries is

$0 \leq \text{HOUR} < 24$

$0 \leq \text{MINUTE} < 60$

A valid entry is saved and displayed to the operator.

Next the operator is prompted to enter the latitude. Entry of the "Back-Up" command transfers control to the release time entry above. An invalid entry causes a reference to the Error Subfunction followed by another prompt. The range of valid entries is

$0 \le$ DEGREES $<$ 90

$0 \le$ MINUTES $<$ 60

DIRECTION = ASCII "N" or "S"

A valid entry is stored and displayed to the operator.

The operator is then prompted to enter the longitude. Entry of the "Back-Up" command transfers control to the latitude entry above. An invalid entry causes the Error Subfunction to be referenced followed by another prompt. The valid range of entries is

$0 \le$ DEGREES $<$ 180

$0 \le$ MINUTES $<$ 60

DIRECTION = ASCII "E" or "W"

Finally the operator is prompted to enter the wind direction in degrees. Entry of the "Back-Up" command transfers control to the longitude entry above. An invalid entry causes the Error Subfunction to be referenced followed by another prompt. The range of valid entries is

$0 \leq \text{Entry} \leq 360$

(If the wind is calm, direction is zero.)

A valid entry is stored and displayed to the operator. Control is transferred to the Processor Subfunction.

3.4.11.1.3 Outputs

a. Operator prompts

b. Station identification

c. Release date and time

d. Latitude and longitude

e. Wind direction

3.4.11.2 Processor Subfunction

3.4.11.2.1 Inputs

a. Environmental Data Set (see 3.4.7)

b. Station identification

c. Release date and time

d. Latitude and longitude

e. Wind direction

3.4.11.2.2 Processing

This subfunction is called by the Station Subfunction. This subfunction computes the dew point temperature, mandatory levels, and heights. All levels in the Environmental Data Set Arrays are assumed to be significant levels and are ordered by decreasing pressures. (That is, the pressure at index i is less than that at index i+1.)

The dew point temperature for each level is computed as follows:

$$\text{Dewpoint}(i) = \text{Temp}(i) - 30 \qquad \text{if Relative Humidity}(i) \leq 19$$
$$= \text{Temp}(i) - \text{Depression} \qquad \text{otherwise}$$

where

i = current index number in the arrays

Temp(i) = temperature array entry

Relative Humidity (i) = Relative Humidity array entry

$$\text{Depression} = 14.55 + (0.114\ \text{Temp}(i))\ \text{Conrel} + (15.9 + 0.117\ \text{Temp}(i))\ \text{Conrel}^{14} + (2.5 + 0.007\ \text{Temp}(i))^3\ \text{Conrel}^3$$

and

$$\text{Conrel} = 1 - \frac{\text{Relative Humidity}(i)}{100}$$

The values for the mandatory levels are computed next. Table 3.4.11-2 lists the mandatory levels.

Table 3.4.11-2. Mandatory Levels in mb

1000	70
850	50
700	30
500	20
400	10
300	7
250	5
200	3
150	2
100	1

If the mandatory level is not significant, the values are found by interpolation. A 20 element flag array (Sig Flag) is used as an aid in this computation. The array keeps track of the total number and the index counter of mandatory levels in the sounding and also the mandatory levels that are significant. The following procedure is used:

a. The array is initialized to -999 throughout.

b. If the mandatory level is also significant (±3mb) the value in the array is set to the index of that level.

c. If the mandatory level is not significant, the array value is set to the negative of the index after the parameters are computed. The following algorithm applies.

Step 1. Set I0 = 1

Step 2. Set the Sig flag element I0 to -999

Step 3. Examine the mandatory pressure indexed by IO. If the mandatory is less than the minimum pressure go to Step 15.

Step 4. Set i = 1.

Step 5. If the mandatory level is outside the limits Pressure(i)-3 $\leq$ mandatory $\leq$ Pressure(i)+3 then go to Step 7.

Step 6. Set Sig flag element IO to 6.

Step 7. If i is less than the maximum number of pressure values stored, then increment i and go to Step 5.

Step 8. If Sig flag element IO is > -900 (that is, the mandatory level is also significant) go to Step 15.

Step 9. The mandatory level must be calculated and inserted. Determine the index number i such that
Pressure(i) < mandatory
If no pressure level is found or the index number is 1 go to Step 15. Otherwise move the pressure, temperature, relative humidity, dewpoint and elapsed time array elements to allow for insertion of the mandatory level at index i.
Set Sig flag element IO to -i.

Step 10. Compute interpolated parameters and insert them in the location corresponding to the index value of i in each array.

Temperature(i) = Temperature (i-1) + K [Temperature (i) - Temperature (i-1)]
Dewpoint(i) = Dewpoint (i-1) + K [Dewpoint(i) - Dewpoint (i-1)]

Relative Humidity(i) =

$$\frac{6.105 \exp\left[\frac{25\ 22(Td-273.2)}{Td} - 5.31 \ln \frac{Td}{273.2}\right]}{6.105 \exp\left[\frac{25.22(Ta-273.2)}{Ta} - 5.31 \ln \frac{Ta}{273.2}\right]} \times 100$$

where

$$K = \frac{\ln\left[\frac{\text{Pressure of Mandatory Level}}{\text{Pressure (i-1)}}\right]}{\ln\left[\frac{\text{Pressure(i)}}{\text{Pressure (i-1)}}\right]}$$

Ta = Temperature(i) + 273.2

Td = Dewpoint(i) + 273.2

Step 11. If Temperature (i) is less than -40 set
Dewpoint(i) = Temperature(i) -30

Step 12. If Relative Humidity(i) is less than 19 set
Dewpoint(i) = Temperature(i) -30

Step 13. If Temperature(i) - Dewpoint(i) is greater than or equal to 29.9 set
Relative Humidity(i) = 19
Pressure(i) = pressure of the mandatory level

Step 14. Set Elapsed time element i to -9.9.

Step 15. If I0 is less than 20, then increment I0 and go to Step 2.

Step 16. Set H0 to height zero and P0 to pressure zero. Compute heights for the levels in the arrays.
Ta = Temperature(i) + 273.2
P1 = Pressure(i)

$$T^*_1 = \frac{0.3794017 \; Ta \; Ee}{Pressure(i) - Ee} + T_a$$

Where

$$Ee = 6.105 \; \frac{Relative\ Humidity(i)}{100} \; \exp\left[\frac{25.22(Ta - 273.2}{Ta} - 5.31 \ln \frac{Ta}{273.2}\right]$$

If this is the surface level set

$T^*_0 = T^*_1$

For all levels

$H1 = H0 + 14.643 \; (T^*_1 + T^*_0) \ln \frac{P0}{P1}$

Set Height(i) = H1

Set up the values for the next iteration

$H0 = H1$

$P0 = P1$

$T^*_0 = T^*_1$

Then repeat the sequence for the next level.

The operator is then queried as to whether a radiosonde listing should be printed. Entry of the "Back-Up" command returns control to the Wind Speed Entry. A "no" entry transfers control to the Skew T Subfunction. Any other entry transfers control to the Sounding Data Subfunction.

3.4.11.2.3 Outputs

Updated Environmental Data Set (with mandatory levels inserted or tagged and geopotential height).

3.4.11.3 Sounding Data Subfunction

3.4.11.3.1 Inputs

Updated Environmental Data Set

3.4.11.3.2 Processing

This subfunction is called by the Processor Subfunction. This subfunction computes the lifting condensation level (LCL), convective condensation level (CCL), level of free convection (LFC), convection temperature (Tc), Showalter Index (SI), and contrail formation criteria.

The lifting condensation level is computed by finding the intersection of the dry adiabat line from the surface temperature and the constant mixing ratio line from the surface dew point temperature. This is the height at which a parcel of air at the surface becomes saturated when mechanically lifted. The convective condensation level is computed by finding the point where the constant mixing ratio line from the surface dew point temperature intersects the ambient temperature profile. This is the height at which a parcel of air at the surface becomes saturated when it is heated from below and rises adiabatically. The critical temperature is the temperature found by following the dry adiabat line from the temperature at the CCL down to the surface. The level of free convection is computed by finding the level at which a parcel of air at the surface would first become warmer than the ambient air when lifted dry adiabatically to the LCL and then moist adiabatically thereafter. In the case of a surface superadiabatic layer, the LCL, CCL, Tc, and LFC are not valid.

The Showalter Index is computed by finding the temperature of the 850 mb LCL, using that temperature to calculate the moist adiabatic potential temperature at 500 mb, and subtracting this temperature from the ambient temperature.

Criteria for contrail formation were taken from tables of critical temperature for jet aircraft contrail formation as a function of pressure and relative humidity for pressures between 500 and 40 mb. Since relative humidity data at these critical temperatures are generally not available, it is assumed that contrails will form in any layer when the ambient temperature is less than the critical temperature at 0 percent relative humidity and that contrails will not form if the ambient temperature is greater than the critical temperature at 100 percent relative humidity. If the ambient temperature falls between these critical temperature values, possible contrail formation is indicated.

Step 1. Is the lapse rate superadiabatic?

$$\text{If } \frac{\text{Temperature (2) - Temperature (1)}}{\text{Height (2) - Height (1)}} \times 10^3$$

is less than or equal to -9.8 go to Step 20.

Step 2. Begin computation of LCL, CCL and TC.
HCCL = 2. If Dewpoint (1) - Temperature (1) < -0.1 go to Step 4.

Step 3. PLCL = Pressure (1)

TLCL = Dewpoint (1)

PCCL = Pressure (1)

TCCL = Dewpoint (1)

TC = Dewpoint (1)

Go to Step 10.

Step 4. Set i = 1

Reference the Compute LCL Subfunction

Step 5. PLCL = LCL Pressure

TLCL = LCL Temperature

IO = Dewpoint (1)

Step 6. For i = 2 through the end of the arrays compute

HCCL = i

$$X = IO + \frac{(IO + 237.3)^2}{4098} \ln \frac{\text{Pressure } (i)}{\text{Pressure } (i - 1)}$$

If |X - Temperature (i) | < 0.1 go to Step 8.

If X - Temperature (i) > 0 go to Step 9.

IO = X

increment i

Step 7. Set HCCL = 1.

Go to Step 10.

Step 8. PCCL = Pressure (i)

TCCL = Dewpoint (i)

Go to Step 10

Step 9. $Y = \dfrac{I0 - \text{Temperature }(i-1)}{\text{Temperature }(i) - \text{Temperature }(i-1) - (X - I0)}$

$$PCCL = \text{Pressure}(i-1)\left[\frac{\text{Pressure }(i)}{(\text{Pressure }(i-1)}\right]^{Y}$$

$$TCCL = \text{Temperature }(i-1) + \left[\ln \frac{PCCL}{\text{Pressure}(i-1)}\right]\left[\frac{\text{Temperature}(i)-\text{Temperature}(i-1)}{\ln \dfrac{\text{Pressure}(i)}{\text{Pressure}(i-1)}}\right]$$

$$Tc = (TCCL + 273.2)\left[\frac{\text{Pressure }(1)}{PCCL}\right]^{0.286} - 273.2$$

Step 10. Begin LFC computation.

HLFC = -1

P = PLCL

T = TLCL

Reference the Theta Moist Subfunction

Step 11. Search the array from Level 2 through the end for a value Pressure (i) $\leq$ P.

If not found go to Step 17.

Step 12. j = i

P = Pressure (j - 1)

Reference the Satlft Subfunction with inputs θmoist and P.

Set I0 to the output temperature.

Step 13. P = Pressure (j)

Step 14. Reference the Satlft Subfunction with inputs θmoist and P.

Set I1 to the output temperature

$$I2 = \frac{Io - I1}{\ln\left[\dfrac{\text{Pressure }(j-1)}{\text{Pressure }(j)}\right]}$$

Step 15. From i=j through the end of the array

$$I3 = I0 + I2 \ \ln\left[\frac{\text{Pressure (i)}}{\text{Pressure (j-1)}}\right]$$

If I3 < temperature (i) increment i and recompute I3.

Step 16. If j < i to to Step 12.

HLFC = j

$$I3 = \frac{\text{I0 - Temperature (j-1)}}{\text{Temperature (j) - Temperature (j-1) -(I1 - I0)}}$$

$$\text{PLFC} = \text{Pressure(j-1)}\left[\frac{\text{Pressure(j)}}{\text{Pressure(j-1)}}\right]^{I3}$$

TFLC = Temperature (j+1) +

$$\ln\left[\frac{\text{PFLC}}{\text{Pressure(i-j)}}\right]\frac{\text{Temperature (j) - Temperature (j-1)}}{\ln\left[\frac{\text{Pressure(j)}}{\text{Pressure(j-1)}}\right]}$$

Step 17. $\text{HLCL} = \text{Height (1)} + \ln\left[\frac{\text{PLCL}}{\text{Pressure (1)}}\right]\left[\frac{\text{Height (2) - Height (1)}}{\ln\frac{\text{Pressure (2)}}{\text{Pressure (1)}}}\right]$

If HCCL < 2 go to Step 21.

i = HCCL.

$$\text{HCCL} = \text{Height(i-1)} + \ln\left[\frac{\text{PCCL}}{\text{Pressure(i-1)}}\right]\left[\frac{\text{Height(i) - Height(i-1)}}{\ln\left[\frac{\text{Pressure(i)}}{\text{Pressure(i-1)}}\right]}\right]$$

If HLFC < 2, go to Step 21.

Step 18. i = HLFC

$$HLFC = Height\ (i-1) + \ln\left[\frac{PLFC}{Pressure\ (i-1)}\right]\left[\frac{Height\ (i) - Height\ (i-1)}{\ln \frac{Pressure\ (i)}{Pressure\ (i-1)}}\right]$$

Go to Step 21.

Step 20. HCCL = -1

HLFC = -1

Step 21. Begin Showalter Index Computation.

SI = -999

If SIG Flag (2) $\leq$ -900 or

SIG Flag (4) $\leq$ -900 go to Step 25.

Step 22. Begin computation of LCL from 850 mb

i = |Sig Flag (2)|

Reference the Compute LCL Subfunction. If LCL Pressure < 500 set SI to -999 and go to Step 25.

Step 23. P = LCL Pressure

T = LCL Temperature

Step 24. Reference the Theta Moist Subfunction.

i = |Sig Flag (4)|

P = Pressure (i)

SI = Temperature (i) - TT

where TT = output of the Satflt Subfunction with inputs θmoist and P.

Step 25. Begin to compute contrails. Zero the control and PSB Control Arrays. (Each array is 11 items long.)

i - 1.

Find the index i where Pressure(i) $\leq$ 500, then go to Step 26. Otherwise transfer control to the List Subfunction.

Step 26. $T1 = f_{100}$ (Pressure(i))

where function f_{100} (P), which computes the temperature for 100 percent relative humidity, is defined as follows:

$$T = \frac{\ln(P) - 9.838293}{0.098738} \qquad P \geq 100$$

$$T = \frac{\ln(P) - 10.456211}{0.110397} \qquad P < 100$$

Step 27. If Temperature(i) $\leq$ T1 go to Step 29.

Step 28. Increment i. If all items in the Temperature array have not been examined, go to Step 26. Otherwise transfer control to the List Subfunction.

Step 29. Contrail formation is possible.

$T0 = f_{100}$ (Pressure(i-1))

where f_{100} was defined in Step 26.

PSB Control (1) = PSB Control (1) + 1

K0 = 2(PSB Control (1))

If K0 > 10 go to Step 37.

Step 30. PSB Control (KO) = Pressure(i-1) $\left[\frac{\text{Pressure(i)}}{\text{Pressure(i-1)}}\right]^{TE}$

where $TE = \frac{\text{T0 - Temperature (i-1)}}{\text{Temperature (i) - Temperature (i-1) - (T1 - T0)}}$

Go to Step 37.

Step 31. T0 = T1.

Increment i.

If all items in the arrays have not been examined go to Step 34.

Step 32. If KO > 10 transfer control to the List Subfunction.

Step 33. PSB Control (KO + 1) = Pressure (N)

where Pressure (N) = last item in the Pressure array.

Transfer control to the List Subfunction.

Step 34. T1 = f_{100} (Pressure (i))

where f_{100} was defined in Step 26.

Step 35. If Temperature (i) $\leq$ T1 go to Step 37.

Step 36. If KO > 10 go to Step 28. Otherwise set

PSB Control (KO + 1) = Pressure(i-1) $\left[\frac{\text{Pressure (i)}}{\text{Pressure(i-1)}}\right]^{TE}$

where TE was defined in Step 30. Go to Step 28.

Step 37. T1 = f_0 (Pressure (i))

where function $f_0(P)$, which computes the temperature for 0 percent humidity, is defined as follows:

$$T = \frac{\ln(P) - 11.203872}{0.107296} \qquad P \geq 100$$

$$T = \frac{\ln(P) - 12.019918}{0.120565} \qquad P < 100$$

If Temperature (i) > T1, go to step 31. Otherwise

T0 = f_0 (Pressure(i-1))

Control (1) = Control (1) + 1

K1 = 2(Control (1))

$$I3 = \text{Pressure}(i-1) \left[\frac{\text{Pressure (i)}}{\text{Pressure}(i-1)}\right]^{TE}$$

where TE was defined in Step 30.

Step 38. If K1 $\leq$ 10 go to Step 39. If K0 > 10 transfer control to the List Subfunction.

PSB Control (K0 + 1) = I3. Transfer control to the List Subfunction.

Step 39. Control (K1) = I3. If K0 $\leq$ 10 set PSB Control (K0 + 1) = I3.

Step 40. T0 = T1. Increment i. If all items in the arrays have been examined set

Control (K1 + 1) = Pressure (N)

where Pressure (N) = the last item in the Pressure array, then transfer control to the List Subfunction.

Step 41. T1 = f_0(Pressure (i))

where f_0 was defined in Step 37. If Temperature (i) $\leq$ T1 go to Step 40.

Step 42. $$\text{Control } (K+1) = \text{Pressure}(i-1) \left[\frac{\text{Pressure (i)}}{\text{Pressure}(i-1)}\right]^{TE}$$

where TE was defined in Step 30.

Step 43. PSB Control (1) = PSB Control (1) + 1

KO = 2(PSB Control (1))

If KO > 10 go to Step 34.

Step 44. PSB Control (KO) = Control (K1 + 1). Go to Step 34.

3.4.11.3.3 Outputs

a. Lifting condensation level parameters

b. Convective Condensation level parameters

c. Level of free convection parameters

d. Convection temperature

e. Showalter Index

f. Control array

g. PSB Control array

3.4.11.4 Theta Moist Subfunction

3.4.11.4.1 Inputs

a. Pressure (P)

b. Temperature (T)

3.4.11.4.2 Processing

This subfunction is called by the Sounding Data Subfunction. This subfunction computes the moist adiabatic potential temperature.

Step 1. If $|P - 1000| > 0.1$ go to Step 2.

$\theta moist = T$

Terminate the algorithm.

Step 2. $\theta Dry = (T + 273.2)\ (\frac{1000}{P})^{0.286} - 273.2$

$\theta moist = \theta dry - f_w(\theta dry) + f_w(T)$

where f_w is the Wobus Function defined as

$$Wobf = \frac{15.13}{Pol^4} \qquad\qquad T\text{-}20 \leq 0$$

where $Pol = 1 + (T\text{-}20)(-8.84166053 \times 10^{-3} + Y)$

$$Y = (T\text{-}20)[1.47141427 \times 10^{-4} + (T\text{-}20)(-9.67198898 \times 10^{-7} + X)]$$

$$X = (T\text{-}20)[-3.26072173 \times 10^{-8} + (T\text{-}20)\ (-3.85980727 \times 10^{-10})]$$

$$Wobf = \frac{29.93}{Pol^4} + 0.96\ (T\text{-}20) - 14.8 \qquad T\text{-}20 > 0$$

where $POL = 1 + (T\text{-}20)(3.6182989 \times 10^{-3} + Z)$

$$Z = (T\text{-}20)]-1.3603273 \times 10^{-5} + (T\text{-}20)\ (4.9618922 \times 10^{-7} + Y)]$$

$$Y = (T\text{-}20)[-6.1059365 \times 10^{-9} + (T\text{-}20)\ (3.9401551 \times 10^{-11} + X)]$$

$$X = (T\text{-}20)[-1.2588129 \times 10^{-13} + (T\text{-}20)\ (1.6688280 \times 10^{-16})]$$

Control is returned to the calling subfunction.

3.4.11.4.3 Outputs

Moist Adiabatic potential temperature (θmoist).

3.4.11.5 Saturated Lifting Subfunction

4.4.11.5.1 Inputs

a. Moist adiabatic potential temperature (θmoist)

b. Pressure (P)

3.4.11.5.2 Processing

This subfunction is called by the Sounding Subfunction. This subfunction computes the temperature which exists when θmoist is lifted to pressure P.

Step 1. If $|P-1000| > 0.1$ then continue with Step 2. Otherwise set T = θmoist and return to the calling subfunction.

Step 2. Compute the following

$Pwrp = (P/1000)^{0.286}$

$T1 = (\theta moist + 273.2)\ Pwrp - 273.2$

$E1 = f_w(T1) - f_w(\theta moist)$

where f_w is the Wobus function defined in the Theta Moist Subfunction

Step 3. $T2 = T1 - (E1)(R)$

$E2 = (T2 + 273.2)/Pwrp - 273.2$

$E2 = E2 + f_w(T2) - f_w(E2) - \theta moist$

$Err = (E2)(R)$

$R = (T2-T1)/(E2-E1)$

$T1 = T2$

$E1 = E2$

If $|Err| > 0.1$ then go to Step 3. Otherwise set

$T = T2-Err$

and return to the calling subfunction.

3.4.11.5.3 Outputs

Temperature (T) when θmoist is lifted to pressure P

3.4.11.6 Compute LCL Subfunction

3.4.11.6.1 Inputs

a. Dewpoint array

b. Temperature array

c. Pressure array

d. Index for level in the arrays (i)

3.4.11.6.2 Processing

This subfunction is called by the Sounding Data Subfunction.

$$A = \frac{\text{Dewpoint (i)} + 273.2}{\text{Temperature (i)} + 273.2}$$

$$I0 = \frac{[\text{Dewpoint (i)} + 273.2]^2}{4098}$$

$$B = \frac{I0}{\text{Temperature (i)} + 273.2}$$

$$\text{LCL Pressure} = \text{Pressure (i)} \ \exp\left[\frac{\text{Dewpoint (i)} - \text{Temperature (i)}}{0.286\ (\text{Temperature (i)} + 273.2) - I0}\right]$$

$$I1 = A + B \ln\left(\frac{\text{LCL Pressure}}{\text{Pressure (i)}}\right) - \left(\frac{\text{LCL Pressure}}{\text{Pressure (i)}}\right)^{0.286}$$

$$I2 = \frac{B}{\text{LCL Pressure}} - \left(\frac{0.286\ (\text{LCL Pressure})}{\text{Pressure (i)}^{0.286}}\right)^{0.286-1}$$

$$\text{LCL Pressure} = \text{LCL Pressure} - \frac{I1}{I2}$$

If $\left|\frac{I1}{I2}\right| > 0.1$ recompute I1 and I2 using the new value for LCL pressure.

Otherwise

$$\text{LCLTemperature} = (\text{Temperature (i)} + 273.2)\left[\frac{\text{LCL Pressure}}{\text{Pressure (i)}}\right]^{0.286} - 273.2$$

Control is returned to the calling subfunction.

3.4.11.6.3 Outputs

a. LCL Pressure

b. Temperature

3.4.11.7 List Subfunction

3.4.11.7.1 Inputs

a. Station Identification
b. Latitude and Longitude
c. Release date and time
d. Wind speed and direction
e. Pressure contact setting
f. Baseline temperature ordinate
g. Baseline relative humidity ordinate
h. Environmental Data Set
i. Dewpoint array
j. Dewpoint Depression array
k. Lifting condensation level parameters
l. Convective condensation level parameters
m. Level of free convection parameters
n. Showalter Index
o. Lapse Rate
p. Control Array
q. PSB Control Array

3.4.11.7.2 Processing

This subfunction is called by the Sounding Data Subfunction. The first page of the radiosonde listing, as shown in Figure 3.4.11-1, is printed using the input values. The stations, location, date and time for the second page, as shown in Figure 3.4.11-1, are then printed. If the lapse rate in the surface layer is less than or equal to -9.8 the message "surface superadiabatic layer, unable to compute LCL", is printed. Otherwise the LCL pressure, temperature, and height are printed.

If the height of the CCL is in the first layer and the lapse rate is less than or equal to -9.8, the message "surface superadiabatic layer, unable to compute CCL", is printed. Otherwise the CCL pressure, temperature, and height, together with the convection temperature are printed.

If the lapse rate is less than or equal to -9.8, the message, "surface superadiabatic layer, no LFC found", is printed. Otherwise the LFC pressure, temperature, and height are printed. If the Showalter Index is undefined the message "unable to compute Showalter Index", is printed. Otherwise the value is printed.

Next an examination for the freezing level is made by searching through the temperature array for a value less than zero. If none is located, the "no freezing level is found" message is printed. If the first level has a temperature less than zero, the "freezing level is at the surface" message is printed. If neither of these two cases apply, the freezing level and pressure are computed.

$$I0 = \frac{\ln\left(\frac{\text{Pressure (i)}}{\text{Pressure (i-1)}}\right)}{\text{Temperature (i) - Temperature (i-1)}}$$

where i = index of the first level where Temperature(i) $\leq$ 0.

$$I1 = \ln(\text{Pressure (i)}) - I0\,(\text{Temperature (i)})$$

$$P = \exp(I1)$$

Compute the height from the pressure

$$H = \text{Height (i-1)} + \ln\left(\frac{P}{\text{Pressure (i-1)}}\right)\left[\frac{\text{Height (i) - Height (i-1)}}{\ln\left(\frac{\text{Pressure (i)}}{\text{Pressure (i-1)}}\right)}\right]$$

The freezing level message at height H and pressure P is then printed.

The search of the temperature array is then resumed at the next level above i. If any more freezing levels are found, the above procedure for computing the pressure and height and printing the message is repeated.

The contrail formation criterion is to be printed next. The following algorithm is used.

Step 1. If PSB Control (1) $\leq$ 0 go to Step 4.

Step 2. Print the header, "Possible Contrail Formation".

Step 3. Set each item in the Contrail array equal to the corresponding item in the PSB Control array. Reference the Contrail Output Subfunction. Terminate the algorithm.

Step 4. If Control (1) $\geq$ 0 go to Step 5. Otherwise print the header, "Contrail Formation." Set each item in the Contrail array equal to the corresponding item in the Control array. Reference the Contrail Output Subfunction. Terminate the algorithm.

Step 5. Print "No Contrail Formation Predicted".

Step 6. Terminate the algorithm.

Finally the pressure altitude and D-values are listed by referencing the D-values Subfunction. Control is then transferred to the Skew T Subfunction.

3.4.11.7.3 Outputs

a. Radiosonde listing

b. Contrail array

3.4.11.8 Contrail Output Subfunction

3.4.11.8.1 Inputs

a. Pressure array

b. Contrail array

c. Height array

3.4.11.8.2 Processing

This subfunction is called by the List Subfunction.

Step 1. Compare each item in the Pressure array to the second item in the Contrail array. If Pressure (i) $\leq$ Contrail (2), go to Step 2. If this condition is never satisfied terminate the algorithm.

Step 2. Set j = 2.

Step 3. If Pressure(i) $\leq$ Contrail(j) go to Step 5.

Step 4. Increment i. If i exceeds the number of items in the Pressure array, terminate the algorithm.

Step 5. P = Contrail(j). Compute height from the pressure.

$$H = \text{Height}(i-1) + \ln \frac{P}{\text{Pressure}(i-1)} \left[\frac{\text{Height}(i) - \text{Height}(i-1)}{\ln \frac{\text{Pressure}(i)}{\text{Pressure}(i-1)}} \right]$$

Step 6. Convert H to feet.
H1 = H/0.3048

Step 7. If Pressure (i) $\leq$ Contrail(j+1) go to Step 9.

Step 8. Increment i. If i exceeds the number of items in the Pressure array, terminate the algorithm. Otherwise go to Step 7.

Step 9. P = Contrail(j + 1). Compute height from pressure using the equation in Step 5. Convert H to feet.
H2 = H/0.3048.

Step 10. Print the lower height (H1) and upper height (H2).

Step 11. Increment j by 2. If j is less than or equal to 10 go to Step 3.

Control is returned to the calling subfunction.

3.4.11.8.3 Outputs

Lower and upper height of contrail formation.

3.4.11.9 D-values Subfunction

3.4.11.9.1 Inputs

Pressure Array

3.4.11.9.2 Processing

This subfunction is called by the List Subfunction. The D-values are computed by taking the difference between the actual height and the standard height of the particular pressure surfaces.

Step 1. j = 1.

Step 2. Zp = 304.8j

Step 3. $P = 1013.2 \left(1 - \frac{0.0065}{288\ Zp}\right)^{5.255}$

Step 4. Search the Pressure array for the first case where P > Pressure (i). If not found, transfer control to the Skew T Subfunction.

Step 5. $H = \text{Height}(i-1) + \ln\left(\frac{P}{\text{Pressure}(i-1)}\right)\left[\frac{\text{Height}(i) - \text{Height}(i-1)}{\ln \frac{\text{Pressure}(i)}{\text{Pressure}(i-1)}}\right]$

Step 6. Z = H

D = (Z - Zp)/0.3048

Step 7. Print Zp and D.

Step 8. Increment j. If j is less than or equal to 10, go to Step 2.

3.4.11.9.3 Outputs

a. Pressure altitude (Zp) listing

b. D-value listing

3.4.11.10 Skew T Subfunction

3.4.11.10.1 Inputs

a. Pressure array

b. Temperature array

c. Dewpoint array

d. Lapse rate

e. LCL parameters

f. CCL parameters

g. LFC parameters

3.4.11.10.2 Processing

This subfunction is called by the Processor and D-Values Subfunctions. The Skew-T, log p diagram is plotted on the scale of chart DOD-WPC 9-16-1 and can be used as an overlay for this chart.

The subfunction queries the operator for a plot. Entry of the "Back-Up" command transfers control to the Sounding Data Subfunction. A "no" entry transfers control to the Encode Subfunction. Any other entry results in the plotting of the Skew T, log p diagram. Control is then transferred to the Encode Subfunction.

3.4.11.10.3 Output

Skew T, log p diagram

3.4.11.11 Encode Subfunction

3.4.11.11.1 Inputs

a. Time and date

b. Latitude and longitude

c. Pressure array

3.4.11.11.2 Processing

This subfunction is called by the Skew T Subfunction. This subfunction generates parts A through D of the message according to sea station format (TEMP SHIP) found in the Federal Meteorological Handbook No. 4. Winds aloft are not included, nor is missing data (other than relative humidity at temperature less than -40^{o}C) encoded. Additional data groups for code figures 40 through 59 can be added to parts B and D as required.

The operator is prompted to request encoding WMO data. A "Back-Up" command entry transfers control to the Skew T Subfunction. A "no" entry transfers control to the Options Function (3.4.10). Any other reply causes encoding to begin.

The identification position groups is set up with the ASCII string "UU" in the first two character positions of the message print buffer and the slash (/) character followed by a blank in positions 11 and 12 of the print buffer.

The date and time (GMT) are encoded next. If the time is greater than or equal to 2315, the date is incremented by one. The resulting value, after adding 50 to the date, is placed in character positions 7 and 8. The time is converted to an hour code as follows:

Hour = 00	$2315 \leq time \leq 2359$
= 06	$0515 \leq time \leq 0600$
= 12	$1115 \leq time \leq 1200$
= 18	$1715 \leq time \leq 1800$
= time rounded to nearest hour	otherwise

The hour is placed in character positions 9 and 10. Character positions 13 and 14 are both set to 9.

The latitude and longitude encoding process sets the latitude in degrees and tenths into character positions 15,16, and 17. The longitude in degrees and tenths occupies character positions 20 through 24. The quadrant is converted to a code number which is stored in character position 19 as follows:

Latitude	Longitude	Code
N	E	1
S	E	3
N	W	7
S	W	5

The Marsden square code is placed in character positions 25, 26 and 27. The coding is developed as follows:

Step 1. Code = INT $\left(\frac{\text{Longitude}}{10}\right)$ + 1

where INT = integer function

Step 2. If longitude is west go to Step 3. Otherwise Code = 37-Code.

Step 3. If latitude $\geq$ 80 go to Step 7.

Step 4. If latitude is north, go to step 6.

Step 5. Code = Code + 299

Step 6. Code = Code + 36[INT ($\frac{\text{Latitude}}{10}$)]
Terminate the algorithm.

Step 7. Code = Code + 900

Step 8. If latitude is north, terminate the algorithm.

Step 9. Code = Code-313.
The code for the latitude and longitude digits for positions 28 and 29 respectively is developed as:

$$\text{Latitude Digit} = \text{Latitude} - 10\ \text{INT}\left(\frac{\text{Latitude}}{10}\right)$$

$$\text{Longitude Digit} = \text{Longitude} - 10\ \text{INT}\left(\frac{\text{Longitude}}{10}\right)$$

The tropopause code group is then generated. The following algorithm is used to locate the tropopause.

Step 1. Set i=2

Step 2. If Pressure (i) > 500 go to Step 12.

Step 3. Δh = Height (i) - Height (i-1)
ΔT = Temperature (i) - Temperature (i-1)
Lapse = $-\Delta T/\Delta h \times 10^3$
If Lapse > 2 go to Step 12.

Step 4. If i is less than the number of items in the arrays
Go to Step 7.

Step 5. Go to Step 13.

Step 6. I3 = i-1.
If Pressure (I3) > 500 go to Step 12.
Go to Step 13.

Step 7. I2 = i. Go to Step 10.

Step 8. I2 = I2+1
If I2 is greater than the number of items in the arrays, go to Step 13.

Step 9. Δh = Height (I2) - Height (i-1)
ΔT = Temperature (I2) - Temperature (i-1)
Lapse = $-\Delta T/\Delta h \times 10^3$
If Lapse > 2 go to Step 12.

Step 10. If Height (I2) > Height (i-1) + 2000 go to Step 6.

Step 11. Go to Step 8.

Step 12. Increment i. If i is less than or equal to the number of items in the arrays go to Step 2.

Step 13. Set characters 1 through 5 of the tropopause buffer to 88999 and characters 13 through 17 to /////.

Step 14. If I3 = 0 transfer control to the Loop Subfunction (3.4.11.16).

Step 15. If Pressure (I3) < 500 go to Step 16.
If the last item in the Pressure array is greater than 200 transfer control to the Loop Subfunction.

Step 16. $i = I3$

$I3 = \text{Pressure }(i)$

Reference the Encode Pressure Subfunction (3.4.11.12).

If I3 < 100. Go to Step 18.

Set the part A tropopause code to the output value.

Step 17. $\text{Pressure }(i) = I3 - 100 \text{ INT}\left(\frac{I3}{100}\right)$

Reference the Encode Pressure Subfunction (3.4.11.12)

Set the part C tropopause code to the output value.

Go to Step 19.

Step 18. Set the part C tropopause code to the output value.

Step 19. $\text{Pressure }(i) = I3$

Reference the Encode Temperature Subfunction (3.4.11.13).

Set characters 7,8, and 9 of the tropopause buffer to the output value.

Step 20. Reference the Encode Dew Point Depression Subfunction (3.4.11.14).

Set characters 10,11, and 12 of the tropopause buffer to the output value.

Step 21. Transfer control to the Loop Subfunction.

3.4.11.11.3 Outputs

a. Identification position code

b. Time of observation code

c. Latitude, longitude, quadrant, and Marsden square code

d. Tropopause code for parts A and C

e. Tropopause buffer

f. Pressure code

g. Temperature code

h. Dew point depression code

3.4.11.12 Encode Pressure Subfunction

3.4.11.12.1 Inputs

a. Pressure array

b. Index value

3.4.11.12.2 Processing

This subfunction is called by the Encode Subfunction.

Step 1. Set I0 to Pressure (i) rounded to the nearest integer.

Step 2. If I0 < 1000 go to Step 4.

Step 3. Code = I0 - 1000 terminate the algorithm.

Step 4. If I0 $\geq$ 100 to to Step 5.
I0 = INT (10 Pressure (i) + 0.5)
If I0 $\leq$ 999 go to Step 5.
I0 = 100

Step 5. Code = I0

Control is returned to the calling subfunction.

3.4.11.12.3 Outputs

Pressure code

3.4.11.13 Encode Temperature Subfunction

3.4.11.13.1 Inputs

a. Temperature array

b. Index value

3.4.11.13.2 Processing

This subfunction is called by the Encode Subfunction. If Temperature (i) is positive, set the code to the temperature in degrees and tenths. If the resulting code is odd, subtract one.

Otherwise, set the code to the temperature in degrees and tenths (ignoring the minus sign). If the resulting code is even, add one. Control is returned to the calling subfunction.

3.4.11.13.3 Outputs

Temperature code

3.4.11.14 Encode Dew Point Depression Subfunction

3.4.11.14.1 Inputs

a. Relative humidity array

b. Temperature array

c. Dewpoint array

d. Index value

3.4.11.14.2 Processing

This subfunction is called by the Encode Subfunction.

Step 1. Depression = 30

Step 2. If Relative Humidity (i) ≤ 19 go to Step 3.
Depression = Temperature (i) - Dewpoint (i)

Step 3. If Depression > 5 go to Step 7.

Step 4. Depression = INT (10 Depression) go to Step 9.

Step 5. If Depression ≥ 10 go to Step 9.

Step 6. Code = Depression.
Go to Step 10.

Step 7. Depression = INT (Depression + 0.5)
If Depression > 5 go to Step 8.
Depression = 0.

Step 8. Depression = 50 + Depression
If Depression ≤ 99 go to Step 9.
Depression = 99.

Step 9. Code = Depression

Step 10. If Temperature (i) ≥ -40 terminate the algorithm. Otherwise set code to //.

Control is returned to the calling subfunction.

3.4.11.14.3 Outputs

Dew point depression code.

3.4.11.15 Encode Height Subfunction

3.4.11.15.1 Inputs

a. Height array

b. Pressure array

c. Index value

3.4.11.15.2 Processing

This subfunction is called by the Encode Subfunction.

Step 1. Set IO to Height (i) rounded to the nearest integer.

Step 2. If Pressure (i) > 500 go to Step 3.

$$IO = INT\left(\frac{IO}{10} + 0.5\right)$$

Step 3. If IO < 10,000 go to Step 5.

Step 4. IO = IO - 10,000
Go to Step 3.

Step 5. If IO < 1000 go to Step 7.

Step 6. IO = IO - 1000.
Go to Step 5.

Step 7. Code = IO
Control is returned to the calling subfunction.

3.4.11.15.3 Outputs

Height code.

3.4.11.16 Loop Subfunction

3.4.11.16.1 Inputs

a. Wind speed and direction

b. Sig Flag array

c. Height array

d. Pressure array

e. Tropopause code for parts A and C

f. Tropopause buffer

g. Identification position code

3.4.11.16.2 Processing

This subfunction is called by the Encode Subfunction. This subfunction prints the various parts of the WMO message. The operator is prompted to enter the part to be printed. The default value is part A. Entry of the "Back-Up" command transfers control to the Skew T Subfunction. Entry of the "End" command transfers control to the Options Function. An invalid entry causes the Error Subfunction to be referenced followed by another prompt. A valid entry causes the algorithm below to be executed. Control returns to the Options Function upon completion.

Step 1. Go to the step indicated corresponding to the operator entry.

Entry	Step
Part A	2
Part B	32
Part C	51
Part D	64

Step 2. Begin part A coding. Clear the print buffer and set the print index to 1. Print the "WMO Code Part A" heading.

Step 3. Set the first 30 characters in the print buffer to the identification position code. Set positions 3 and 4 to AA. Set the print index to 31.

Step 4. Encode surface pressure, temperature, and dew point depression. Set the first two character positions of a temporary print buffer to 99. Set index i to 1.

Reference the Encode Pressure Subfunction and place the output in characters 3 through 5 of the temporary buffer. Reference the Encode Temperature Subfunction and place the output in characters 7 through 9 of the temporary buffer. Reference the Encode Dew Point Depression Subfunction and place the output in characters 10 and 11 of the temporary buffer.

Step 5. Begin to encode surface wind speed and direction.

$$I0 = \text{Direction} - 10\ \text{INT}\left(\frac{\text{Direction}}{10}\right)$$

where Direction = wind direction

Step 6. I1 = 0

If I0 < 2.5 go to Step 7.

If I0 > 7.5 go to Step 8.

I1 = 500

Step 7. $IO = INT\left(\frac{\text{Direction}}{10}\right)$

Go to Step 9.

Step 8. $IO = INT\left(\frac{\text{Direction}}{10}\right) + 1$

Step 9. Set characters 13 and 14 of the temporary buffer to IO.

Step 10. IO = INT (1.9426 Wind + 0.5 + I1)

where Wind = wind speed

Step 11. Set characters 15 through 17 of the temporary buffer to IO.

Step 12. Set characters 31 through 47 of the print buffer equal to the temporary buffer.

Step 13. Begin coding of mandatory levels for part A.

Set the print buffer character index to 49.

I2 = 0.

Set each item in a 10 item temporary array to -1.

For each of the first 10 items in the Sig Flag array greater than or equal to -900, convert the entry to its absolute value and store it in the corresponding position of the temporary array. Increment I2 each time an appropriate value is found.

Step 14. If I2 > 0 go to Step 15.

Print the "No Mandatories Exist" message then go to Step 28.

Otherwise I1 = 1

Step 15. Set IO to each of the mandatory levels listed in Table 3.4.11-2. (Between 1000 mb and 100 mb) as indexed by I1. Set the first two characters of the temporary print buffer to the level code.

Step 16. If I0 > Pressure (1) to to Step 22.

Step 17. If item I1 of the temporary array is less than zero go to Step 26.

Step 18. Set i to the value in the temporary array as indexed by I1. Reference the Encode Height Subfunction and set characters 3 through 5 of the temporary print buffer to the output.

Step 19. Set the next 5 characters of the print buffer (beginning at the print index position) to the temporary print buffer.

Step 20. Increment the print index by 6. If the print buffer is full, print it, set the print index to 1, and clear the buffer.

Step 21. Reference the Encode Temperature Subfunction and set characters 1 through 3 of the temporary buffer to the output. Reference the Encode Dew Point Depression Subfunction and set characters 4 and 5 of the temporary buffer to the output. Go to Step 25.

Step 22.

$$J = \text{Height}(1) + \left[\frac{\ln\left[\frac{1000}{\text{Pressure}(1)}\right]\left[\text{Height}(2) - \text{Height}(1)\right]}{\ln\left[\frac{\text{Pressure}(2)}{\text{Pressure}(1)}\right]}\right]$$

If J > 0 go to Step 23.

$J = |J| + 500$

Step 23. Set characters 3 through 5 of the temporary buffer to J. Set the next 5 characters in the print buffer (beginning at

the print index) to the temporary buffer.
Check for a full print line by first incrementing the print index by 6. If the print buffer is full, print it, set the print index to 1, and clear the buffer.

Step 24. Set the next 5 characters of the print buffer (beginning at the print index) to /////.
Check for a full print line as in Step 23.
Set the first 5 character positions of the temporary buffer to /////.

Step 25. Set the next 5 characters of the print buffer to the temporary buffer. Check for a full print line as in Step 23.

Step 26. Increment I1. If I1 is less than or equal to 10 go to Step 15.

Step 27. Set characters 3 through 5 of the tropopause buffer to the tropopause code for part A.
If the tropopause is found in part A go to Step 28. Otherwise set the next 5 characters of the print buffer to 88999.
Check for a full print line as in Step 23.
Go to Step 32.

Step 28. Set the next 5 characters of the print buffer (beginning with the print index) to characters 1 through 5 of the tropopause buffer.

Step 29. Check for the full print line as in Step 23.

Step 30. Set the next 5 characters (beginning with the print index) of the print buffer to characters 7 through 11 of the tropopause buffer.
Check for a full print line as in Step 23.

Step 31. Set the next 5 characters (beginning with the print index) to characters 13 through 17 of the tropopause buffer.
Check for a full print line as in Step 23.

Step 32. Set the next 5 characters of the print buffer (beginning with the print index) to 77999 and print the buffer.
Transfer control back to the operator entry at the start of this subfunction.

Step 33. Begin part B coding.
Clear the print buffer and reset the print index to 1.
Zero a 50 item temporary array.

Step 34. Set the first item of the temporary array to 1.
Print the "WMO Code Part B" heading

Step 35. I1 = 2.
i = 2.

Step 36. If pressure (i) < 100 go to Step 39.
Search through the Sig Flag array for a value equal to -i. If found go to Step 38.

Step 37. Set the item in the temporary array as indexed by I1 to i.
Increment I1.

Step 38. Increment i. If i is not equal to the number of items in the pressure array, go to Step 36.

Step 39. Set the first 30 characters in the print buffer to the identification position code.
Set positions 3 and 4 to BB.
Set the print index to 31.
I2 = 0

Step 40. I1 = I1-1.

If I1 $\leq$ 0 go to Step 53.

Step 41. I3 = 1.

Step 42. Set i equal the value in the temporary array as indexed by I3. Set characters 1 and 2 of the temporary buffer to I2.

Step 43. Increment I2.

$I2 = I2 - 10\ \mathrm{INT}\left(\frac{I2}{10}\right)$

If I2 $\neq$ 0 go to Step 44.

I2 = 1.

Step 44. Reference the Encode Pressure Subfunction and place the result in characters 3 through 5 of the temporary buffer.

Set the next 5 characters of the print buffer (beginning with the print index) to the temporary buffer. Check for a full print line as in Step 23.

Step 45. *Reference the Encode Temperature Subfunction and* place the results in characters 1 through 3 of the temporary buffer.

Reference the Encode Dew Point Depression Subfunction and place the results in characters 4 and 5 of the temporary buffer.

Set the next 5 characters of the print buffer (beginning with the print index) to the temporary buffer. Check for a full print line as in Step 23.

Step 46. Increment I3. If I3 is less than or equal to I1 go to Step 42.

Step 47. Prompt the operator for additional data groups. (The default is yes.) If the "Back-Up" command is entered transfer control to the original operator entry point in this subfunction. If the entry is "No" go to Step 52.

Step 48. Set the next 5 characters in the print buffer (beginning with the print index) to 51515.
Check for a full print line as in Step 23.

Step 49. Prompt the operator to enter the code group. Entry of the "Back-Up" command transfers control to the original operator entry point in this subfunction. Entry of the "End" command transfers control to Step 52.
If the entry is within the limits
$42 \leq$ entry ≤ 59 go to Step 51.

Step 50. Reference the Error Subfunction, then go to Step 49.

Step 51. Set the next 5 characters of the print buffer (beginning with the print index) to 101 followed by the entry.
Check for a full print line as in Step 23.
Go to Step 49.

Step 52. If there are any characters in the print buffer, print it.
Go to the original operator entry point for this subfunction

Step 53. Print the "No Data" message then go to the original operator entry point for this subfunction.

Step 54. Begin part C coding.
Clear the print buffer and set the print index to 1.
Print the "WMO Code Part C" heading.
Set character 1 through 30 of the print buffer to the identification position code.
Set characters 3 and 4 of the print buffer to CC.
Set the print index to 31.

Step 55. I2 = 0

Set all items in a 10 item temporary array to -1.

i = 11.

Step 56. If Sig Flag (i) < -900 go to Step 58.

Step 57. Set item i-10 of the temporary array to |Sig Flag (i)|.

Increment I2.

Step 58. Increment i. If i is not 20, go to Step 56.

Step 59. If I2 = 0 print the "No Mandatories Exist for Part C" message. Then go to the original operator entry point for this subfunction.

Step 60. I1 = 1

Step 61. Set I0 to each of the mandatory levels listed in Table 3.4.11-2 (between 70 mb and 1 mb) as indexed by I1.

If item I1 of the temporary buffer is less than zero, go to Step 64.

Set the first two characters of the temporary print buffer to the level code.

Step 62. Set i to the temporary array value as indexed by I1.

Reference the Encode Height Subfunction and set characters 3 through 5 of the temporary buffer to the output.

Set the next 5 characters of the print line (beginning with the print index) to the temporary buffer. Check for a full print line as in Step 23.

Step 63. Reference the Encode Temperature Subfunction. Set characters

1 through 3 of the temporary buffer to the output.
Reference the Encode Dew Point Depression Subfunction. Set characters 4 and 5 of the temporary buffer to the output.
Check for a full print line as in Step 23.

Step 64. Increment I1. If I1 is not 10, go to Step 61.

Step 65. Set characters 3 through 5 of the tropopause buffer to the part C tropopause code.
If the tropopause ends in part C, go to Step 66.
Set the next 5 characters in the print line (beginning with the print index) to 88999. Check for a full print line as in Step 23, then go to Step 32.

Step 66. Transfer characters 1 through 5 from the tropopause buffer to the print buffer (beginning at the print index). Check for a full print line as in Step 23.
Transfer characters 7 through 11 from the tropopause buffer to the print buffer (beginning at the print index). Check for a full print line as in Step 23.
Transfer characters 13 through 17 from the tropopause buffer to the print buffer (beginning at the print index). Check for a full print line as in Step 23. Go to Step 32.

Step 67. Begin part D coding
Clear the print buffer and set the print index to 1.
Print the "WMO Code Part D" heading.
Clear a temporary 50 item array.
I1 = 1.

Step 68. Find the first item in the pressure array less than 100, then go to Step 69.
If none is found, go to Step 72.

Step 69. I2 = 1

Step 70. Starting at item number 11, search for a value in the Sig Flag array equal to -I2. If found go to Step 71.
Set the temporary array item indexed by I1 to I2.
Increment I1.

Step 71. Increment I2. If I2 is not equal to the number of items in the Sig Flag array go to Step 70.

Step 72. Set the first 30 characters in the print line to the identification position code.
Set characters 3 and 4 of the print line to DD.
Set the print index to 31.

Step 73. I2 = 1.

Step 74. Go to Step 40.

3.4.11.16.3 Output

WMO message code listing.

3.4.11.17 Set-Up Subfunction

3.4.11.17.1 Inputs

None.

3.4.11.17.2 Processing

The Set-Up Subfunction is used to initialize the default values of all variables and arrays. The lengths of character variables and dimensions for all arrays are established. All files are assigned symbolic names.

3.4.11.17.3 Outputs

None.

3.4.11.18 Error Subfunction

3.4.11.18.1 Inputs

None.

3.4.11.18.2 Processing

This subfunction is referenced by any other subfunction to display a message to the operator indicating that an invalid or erroneous response has been made in response to a prompt. A mass storage device error also causes a reference to this subfunction.

In case of a mass storage device error, this subfunction causes a fatal error after informing the operator that a malfunction has occurred with the mass storage device. Any diagnostic information available is also displayed to the operator, then the processor is halted.

3.4.11.18.3 Outputs

Message displayed to operator.

3.4.12 Refractometer Function

This function reads the refractometer data from the Memodyne 3122 Cartridge Magnetic Tape Unit (CMTU) and generates a finite straight-line segment approximation for the altitude/refractivity contour. The data is also formatted for use by other IREPS functions.

The first plot from this function, shown in Figure 3.4.12-1, is an altitude vs time display. The operator selects two time values on this curve to define a flight segment. A plot of altitude vs refractivity for that segment is then displayed, as shown in Figure 3.4.12-2. Finally the operator selects up to 29 straight-line segments that approximate the altitude-versus-refractivity curve.

3.4.12.1 Read Subfunction

3.4.12.1.1 Inputs

Refractometer data tape

3.4.12.1.2 Processing

The Set-Up Subfunction is referenced followed by an operator prompt to enter the source of data, which includes:

a. Mass storage

b. Memodyne CMTU

c. End

If the operator selects mass storage, the refractometer data last saved on the mass storage device is read and control transfers to the Plot Options Subfunction (3.4.12.3). If the Memodyne CMTU is

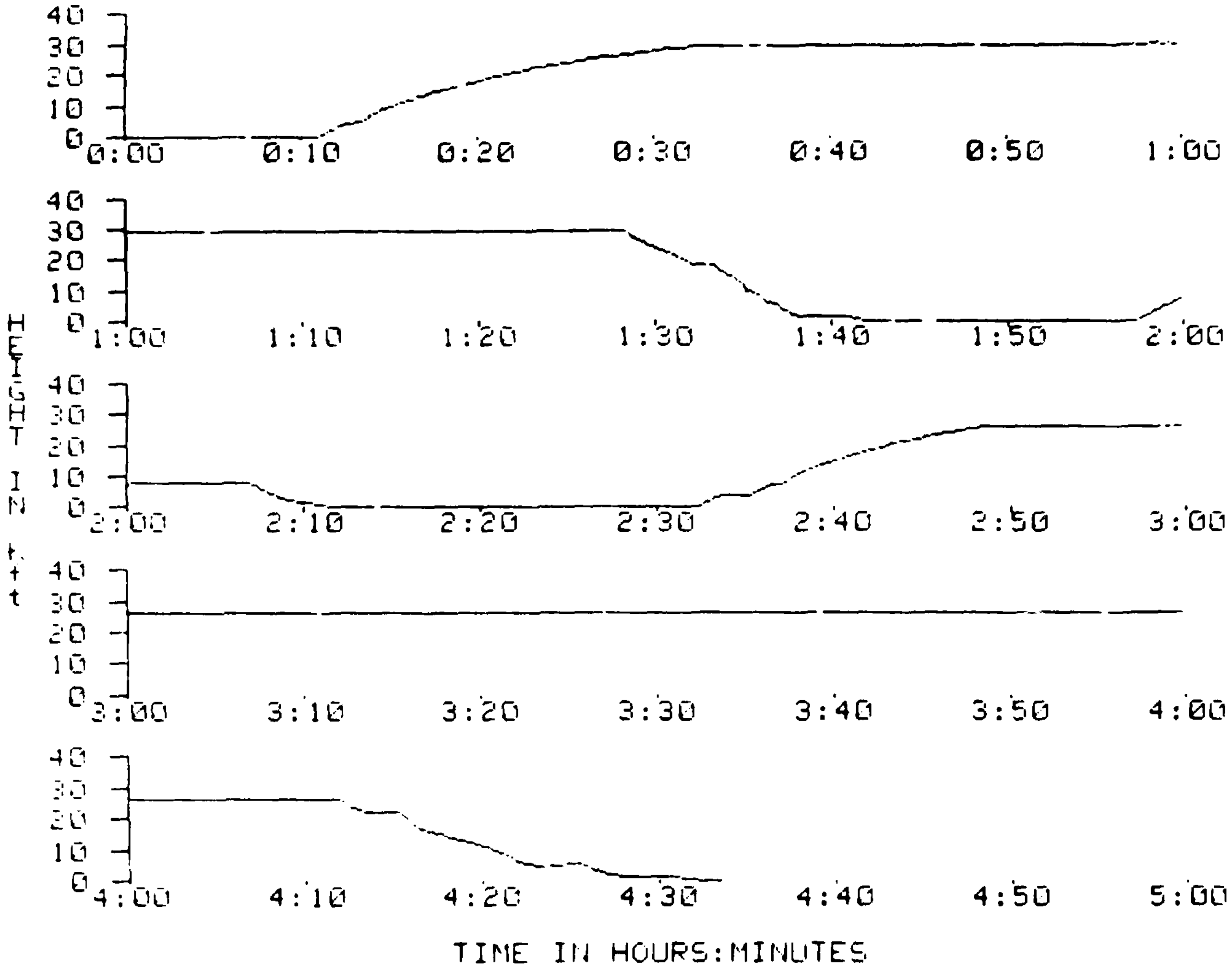
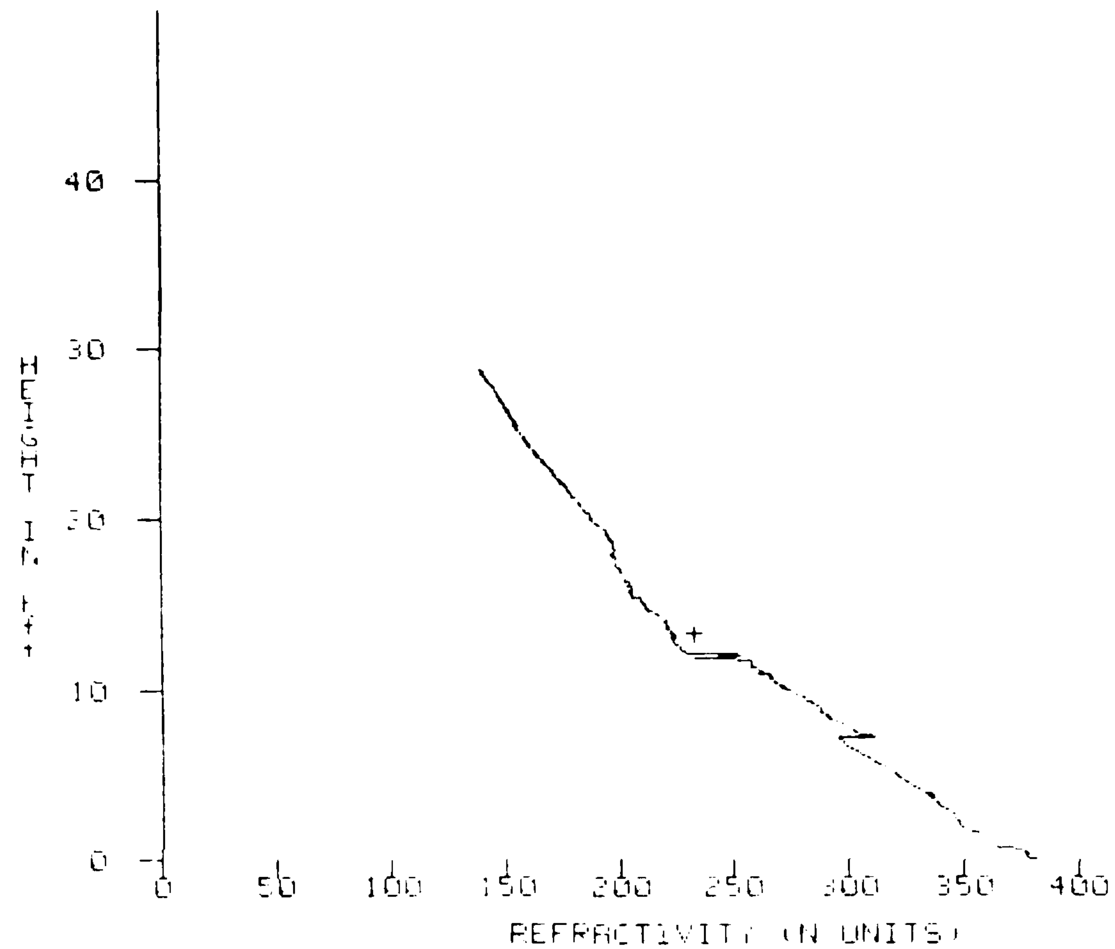


Figure 3.4.12-1. Typical Altitude versus Time Display



Enter levels (29 MAX) and press 'CONT'
Press 'HOME' 'CONT' to end. Heights must be increasing

Figure 3.4.12-2. Typical Flight Segment Display selected, the tape reading begins. If "End" or the "Back-Up" command is entered, the Input Function (3.4.7) is loaded from mass storage and executed. An invalid entry causes the Error Subfunction to be referenced then reprompts the operator.

Reading begins with the initialization of the reader I/O port. The port is reset, then a command to inactivate the CMTU is issued. The operator is prompted to load the cartridge.

The Memodyne I/O interface uses only one control bit to start or stop the motor. The status of the CMTU can be determined from six status bits as listed in Table 3.4.12-1. The data is transferred as a 16-bit parallel word.

The 16-bits represent one data sample. The meanings assigned to the bits are:

Bit Number

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Identification Field	BCD Digit 2	BCD Digit 1	BCD Digit 0
	Data	Data	Data

The identification field is a hexadecimal digit. The data field consists of three binary coded decimal (BCD) digits. BCD digit 0 is the least significant digit and BCD digit 2 is the most significant.

Table 3.4.12-2 lists the meanings assigned to the identification codes.

TABLE 3.4.12-1

MEMODYNE CMTU STATUS BITS

Purpose	Settings
Data Ready	0 = True 1 = False
End Of File (EOF)	1 = True 0 = False
Cartridge In Place	0 = True 1 = False
Beginning/End Of Tape	0 = True 1 = False
Tape Stopped	0 = True 1 = False
Tape Rewinding	0 = True 1 = False

TABLE 3.4.12-2

IDENTIFICATION DIGIT CODE

Digit (Binary)	Meaning
0000	Static Pressure
0001	Static Pressure, No Lock
0010	Lo Cal Test Point
0011	Lo Cal No Lock Test Point
0100	Refractivity
0101	Not Used
0110	High Cal Test Point
0111	Not Used
1000	Air Temperature
1001	Not Used
1010	AFC Test Point
1011	Not Used
1100	Pitot Pressure
1101	Not Used
1110	ID Test Point
1111	Not Used

The data is read in 4-word blocks. If the current block does not consist of exactly the following sequence of identification digit fields

0000	Static Pressure
0100	Refractivity
1000	Air Temperature
1100	Pitot Pressure

the entire block is discarded. The data is also discarded if any BCD digit exceeds 9. An error print out informs the operator of the data being discarded.

The data is written on the tape at a rate of one 4-word data block each 2-seconds of flight time. This function will read a maximum of 9000 blocks (equivalent to 5 hours of flight).

The raw data is converted to more suitable units using the following equations

$$\text{Static Pressure} = 300 + \frac{3SP}{4} \text{ mb.}$$

where SP = raw static pressure value

$$\text{Refractivity} = \frac{R}{2} \text{ N units}$$

where R = raw refractivity value

$$\text{Air Temperature} = \frac{T - 500}{10}\ {}^{o}C$$

where T = raw temperature value

$$\text{Impact Pressure} = 300 + \frac{3PT}{4} - \text{Static Pressure mb.}$$

where PT = raw pitot pressure

The 4 second moving average of impact pressure is then found

$$\bar{P} = \frac{\text{Impact Pressure (j-1) - Impact Pressure(j)}}{2}$$

where Impact Pressure(j-1) = previous reading

Impact Pressure(j) = present reading

An average air temperature over the last 2.7 minutes is computed by using a moving average by

$$\bar{T} = \frac{\sum_{i=1}^{81} \text{Air Temperature}(i)}{81}$$

The refractivity is converted to corrected N units with the following equation.

$$N = \text{Refractivity} + 0.1\ \bar{P} + 0.6\ (\text{Air Temperature} - \bar{T})$$

The aircraft altitude is then found from

$$\text{Altitude} = 145.454 \left[1 - \frac{\text{Static Pressure}}{1013.25} \right]^{0.19025}$$

Control is then transferred to the Plot Subfunction.

3.4.12.1.3 Outputs

a. Static pressure

b. Refractivity in N units

c. Corrected N unit refractivity array values

d. Air temperature

e. Average air temperature

f. Impact pressure

g. Average impact pressure

h. Aircraft altitude array values

3.4.12.2 Plot Subfunction

3.4.12.2.1 Inputs

Aircraft altitude array values

3.4.12.2.2 Processing

The plot of the altitude in thousands of feet versus time is prepared by this function. Only every fifth point in the altitude is plotted, hence the plotting interval is 10 seconds. This function also labels the axes and prints the time intervals on the display. Control is then transferred to the Plot Options Subfunction.

3.4.12.2.3 Outputs

Height versus time plot.

3.4.12.3 Plot Options Subfunction

3.4.12.3.1 Inputs

None

3.4.12.3.2 Processing

This subfunction is called by the Plot Subfunction. If the operator has reached this subfunction from the Plot Subfunction, a query asks if the data is to be replotted. (The default is yes.) A "Back-Up" command or "no" reply transfers control to the Read Subfunction (3.4.12.1). An invalid reply causes the Error Subfunction to be referenced followed by another prompt. A "yes" reply transfers control back to the Plot Subfunction where another copy of the height versus time plot is produced.

If the operator reached this subfunction as a result of specifying the mass storage device as the source of the data, a query asks if a section of the plot is to be retrieved. (The default is yes.) A "Back-Up" or "no" reply transfers control to the Read Subfunction. An invalid reply causes the Error Subfunction to be referenced followed by another prompt. A "yes" reply causes control to transfer to the Retrieve Subfunction (3.4.12.5).

If control did not reach this subfunction for either of the above reasons, the operator is prompted to save the data on the mass storage device. (The default is yes.) Entry of the "Back-Up" command transfers control to the Read Subfunction. A "no" reply transfers control to the prompt for retrieving a section of the plot above. An invalid entry causes a reference to the Error Subfunction followed by another prompt. A "yes" reply transfers control to the Save Data Subfunction.

3.4.12.3.3 Outputs

Operator prompts

3.4.12.4 Save Data Subfunction

3.4.12.4.1 Inputs

a. Aircraft altitude array

b. Corrected N units refractivity array

3.4.12.4.2 Processing

This subfunction is called by the Plot Options Subfunction. This subfunction writes the aircraft altitude array and corrected N units array on the mass storage device media. Control is returned to the calling subfunction.

3.4.12.4.3 Outputs

Refractometer data stored on mass storage device

3.4.12.5 Retrieve Subfunction

3.4.12.5.1 Inputs

Refractometer data on the mass storage device

3.4.12.5.2 Processing

This subfunction is called from the Plot Options Subfunction. The operator is prompted to designate the beginning and ending time for the flight segment display. Using those limits the x-axis labels in eight increments are plotted together with a y-axis label in four 10,000 ft increments of height. The refractivity data within that range is retrieved from the mass storage device and plotted.

The operator is then prompted to enter from 2 to 29 levels in increasing order of height. If an entry is not made in increasing order, a warning message is printed and that value is discarded. After the last point is entered, a listing for the levels is printed out. Within the designated range, the height array, N units array, and M units array of the Environmental Data Set (see 3.4.7) are set to the values from the aircraft altitude array and the corrected N units refractivity array as follows:

$$\text{Height}(i) = 0.3048\ A(j)$$

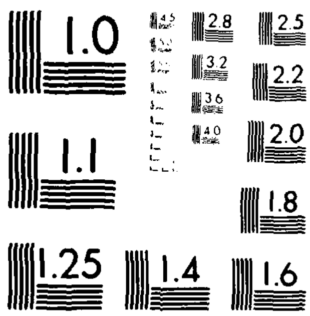
$$\text{N Units}(i) = R(j)$$

$$\text{M Units}(i) = \frac{R(j) + \text{Height}(i)}{6.371}$$

AD-A092 297   MEGATEK CORP SAN DIEGO CA   F/6 20/14
INTEGRATED REFRACTIVE EFFECTS PREDICTION SYSTEM (IREPS): PROGRA--ETC(U)
JUL 80 H V HITNEY, E W PASAHOW, M E O'BRIAN   N00123-78-C-0043
UNCLASSIFIED R2018-059-IF-2   NOSC-TD-365   NL

5 of 5
AD
A092297

END
DATE
FILMED
1 81
DTIC



MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

where i,j = counters for the arrays

A = aircraft altitude array value

R = corrected N units refractivity array value

Control is then transferred to the Input Function (3.4.7).

3.4.12.5.3 Outputs

a. Operator prompts

b. Environmental Data Set

3.4.12.6 Set-Up Subfunction

3.4.12.6.1 Inputs

None

3.4.12.6.2 Processing

This subfunction is called by the Read Subfunction. The Set-Up Subfunction is used to initialize the default values of all variables and arrays. The lengths of character variables and dimensions for all arrays are established. All files are assigned symbolic names. Control returns to the calling subfunction.

3.4.12.6.3 Outputs

None

3.4.12.7 Error Subfunction

3.4.12.7.1 Inputs

None

3.4.12.7.2 Processing

This subfunction is referenced by any other subfunction to display a message to the operator indicating that an invalid or erroneous response has been made in response to a prompt. A mass storage device error also causes a reference to this subfunction.

In case of a mass storage device error, this subfunction causes a fatal error after informing the operator that a malfunction has occurred with the mass storage device. Any diagnostic information available is also displayed to the operator, then the processor is halted.

3.4.12.7.3 Outputs

Message displayed to operator.

3.4.13 Summary Function

The purpose of the Summary Function is to prepare the Propagation Conditions Summary Report. A typical report generated by this function is shown in Figure 3.4.13-1. This report shows the existing refractive conditions for the location, date, and time of the environmental data set. It also gives a narrative assessment of what effects may be expected on an EM system-independent basis. The summary shows a modified refractivity in M-units plot against altitude. The presence and vertical extent of any surface or elevated ducts are shown by shaded areas on the vertical bar at the right-hand side of the report.

3.4.13.1 Summary Entry Subfunction

3.4.13.1.1 Inputs

Environmental Data Set

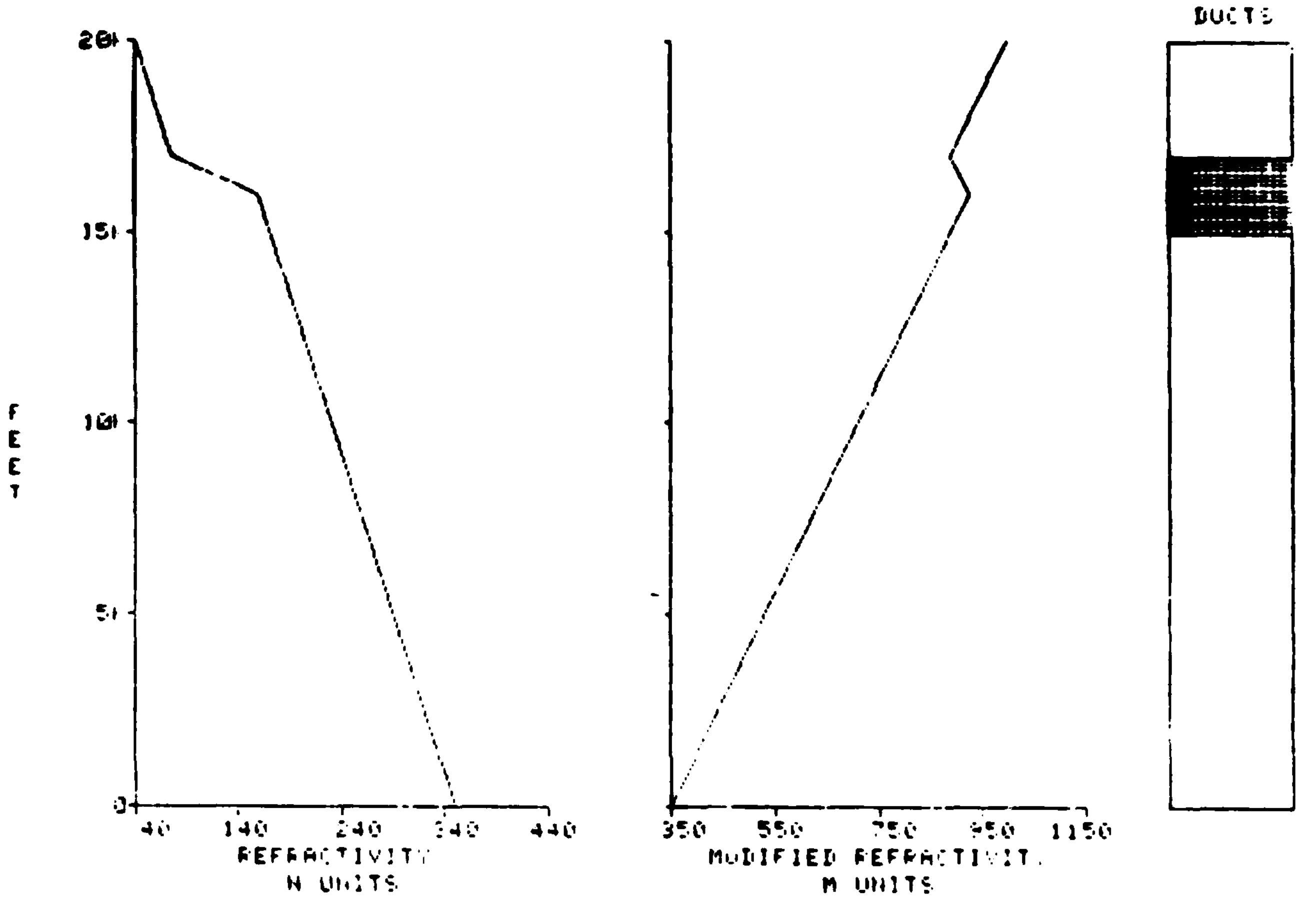
3.4.13.1.2 Processing

This subfunction is called by the Options Subfunction. The Set-Up Subfunction is referenced to initialize data items. If the height units flag is set for metres, the height factor is set to 1. Otherwise, it is set to 1/0.3048.

Next the maximum height for the plot is found. As part of this process the range for the N and M units scales and locations of tick marks are determined. Control is transferred to the Plot Axis Subfunction.

**** PROPAGATION CONDITIONS SUMMARY ****

LOCATION: NOT SPECIFIED
DATE/TIME: EL DUCT 15 TO 17 KFT



WIND SPEED 0.0 KNOTS

EVAPORATION DUCT HEIGHT 0.0 FEET
EVAPORATION DUCT HEIGHT 0.0 METERS

SURFACE-TO-SURFACE

NORMAL RANGES AT ALL FREQUENCIES

SURFACE-TO-AIR

NORMAL RANGES AT ALL ALTITUDES.

AIR-TO-AIR

EXTENDED RANGES FOR ALTITUDES BETWEEN 15,000 AND 17,000 FEET
POSSIBLE HOLES FOR ALTITUDES ABOVE 17,000 FEET

SURFACE REFRACTIVITY: 350 --SET SPS-48 TO 344

Figure 3.4.13-1. Typical Propagation Conditions Summary

3.4.13.1.3 Outputs

a. Maximum height for plots

b. N and M units ranges

c. Locations for tick marks

3.4.13.2 Plot Axis Subfunction

3.4.13.2.1 Inputs

a. Maximum height for plots

b. N and M units ranges

c. Locations for tick marks

3.4.13.2.2 Processing

This subfunction is called by the Summary Entry Subfunction. This plotting subfunction creates the axes for the N units, M units, and ducting displays. The individual functions for the N unit and M unit refractivity are plotted. Finally the shaded area on the "ducts" display is drawn. The plots are displayed by the Summary Output Subfunction.

3.4.13.2.3 Outputs

a. Axes and plots of N-units and M-units

b. Ducting display

3.4.13.3 Summary Output Subfunction

3.4.13.3.1 Inputs

a. Location

b. Date and time

c. Wind speed

d. Evaporation duct height

e. N units array

3.4.13.3.2 Processing

This subfunction is called by the Plot Axis Subfunction. This subfunction titles the display and prints the location, date, and time above the graphics displays. The plots are then displayed with properly labeled axes.

Next a print out of the wind speed and evaporation duct height in feet and metres is presented. Summaries of surface-to-surface, surface-to-air, and air-to-air conditions are prepared in accordance with the following algorithm.

Step 1. If there are no surface or elevated ducts go to Step 3.

Step 2. If the bottom level of the highest duct is less than or equal to 0.1m go to Step 4.

Step 3. The evaporation duct height is examined to see if the "extended range for all frequencies above fn GHz" message should be printed. Depending on the value of d, the following actions are taken.

a.	No message	$5 < \delta$
b.	fn = 10	$5 \leq \delta < 11$
c.	fn = 8	$11 \leq \delta < 13$
d.	fn = 6	$13 \leq \delta < 15$
e.	fn = 4	$15 \leq \delta < 20$
f.	fn = 2	$20 \leq \delta < 30$
g.	fn = 1	$30 \leq \delta < 45$
h.	No message	$\delta \geq 45$

If condition a above is satisfied go to Step 6. If any of conditions b through g are satisfied go to Step 7.

Step 4. Print the "extended ranges at all frequencies" message.

Step 5. Go to Step 7.

Step 6. Print the "normal ranges at all frequencies" message.

Step 7. Print the "surface-to-air" heading. If there are no surface or elevated ducts or if the bottom level of the highest duct is greater than 0.1m, then print the "normal ranges at all altitudes" message. Go to Step 9.

Step 8. Print the "extended ranges for altitudes up to a_1" and "possible holes for altitude above a_2" message, where a1, a2 = top level of the highest duct.

Step 9. Print the "air-to-air" heading. If there are no surface or elevated ducts print the "normal ranges for all altitudes" message then go to Step 14.

Step 10. For each surface or elevated duct (starting with the highest) which has a bottom level less than or equal to 0.1 m print the "extended ranges for altitudes up to a3" message, where a3 equals the top level of that duct.

Step 11. For each surface or elevated duct (starting with the highest) which has a bottom level greater than 0.1m print the "extended ranges for altitudes between a4 and a5" message where
a4 = bottom level of duct
a5 = top level of duct.

Step 12. If there is only one surface or elevated duct print the "possible holes for altitudes above a6" message, where a6 is the top of the duct, then go to Step 14.

Step 13. For each of the remaining ducts (starting with the highest) print the "possible holes for altitudes between a7 and a8" message where
a7 = top of duct i
a8 = bottom of duct i-1. Go to Step 14.

Step 14. Find the value for the SPS-48 setting. The value is one of those listed in Table 3.4.13-1.

Table 3.4.13-1.
Surface N Values for the SPS-48

Index	Value
1	200
2	252
3	289
4	313
5	344
6	377
7	404
8	450

The value chosen is the one closest to the maximum value in the N Units array.

Step 15. Print out the surface refractivity (maximum N units array value) and the SPS-48 setting found in Step 14.

3.4.13.3.3 Outputs

Propagation Conditions Summary Report.

3.4.14 Surface Search Function

This function generates a table of minimum, maximum, and average detection ranges for U.S. and Soviet ships based on the type of radar and antenna height. The surface search radar may be either the AN/SPS-10 or AN/SPS-55. An example of a radar range table is shown in Figure 3.4.14-1. The classes of ships listed in that figure are always used for this print out.

3.4.14.1 Surface Search Entry Subfunction

3.4.14.1.1 Inputs

Environmental Data Set

3.4.14.1.2 Processing

The Set-Up Subfunction is referenced and the operator is prompted to enter the type of radar desired. (The default is the AN/SPS-10.) Entry of the "Back-Up" command transfers control to the Options Function (3.4.10). An invalid entry causes the Error Subfunction to be referenced followed by another prompt.

A valid entry generates a new prompt for the operator to enter the radar heights above the water line. (The default value is 80 feet.) Entry of the "Back-Up" command returns control to the radar type prompt above. A valid entry is in the range

$$3 \leq \text{entry} \leq 250$$

***** SURFACE SEARCH RANGE TABLE *****

LOCATION:31 56N 118 36W
TIME:17 JUN 0045Z

SURFACE SEARCH RADAR: SPS-10

RADAR ANTENNA HEIGHT: 80 FEET

U S SHIP TYPE/CLASS	DETECTION RANGE IN NM		
	MAX	MIN	AVE
CV/CVN	30	27	28
CG/CGN	35	24	29
DD/DDG	52	33	42
FF/FFG	43	27	35
LCC	22	21	21
LHA	39	23	31
LPH	37	23	30
LKA	38	21	29
LPD	49	29	39
LSD	44	27	35
LST	42	31	36
AE/AF	26	21	23
AO/AOE/AOR	52	34	43

SOVIET SHIP TYPE CLASS	DETECTION RANGE IN NM		
	MAX	MIN	AVE
KIEV CLASS	41	28	34
MOSKVA CLASS	39	38	38
CLG	50	33	41
CG/CC/CA	30	19	24
DD/DDG	41	22	31
FRIGATE	43	29	36
CORVETTE	38	28	37
OSA/STENKA CLASS	36	31	33
PRIMORYE CLASS AGI	36	33	34
LENTRA CLASS AGI	50	35	42
OKEAN CLASS AGI	32	24	28

Figure 3.4.14-1. Typical Surface Search Radar Range Table

An invalid entry causes the Error Subfunction to be referenced followed by another prompt. A valid entry transfers control to the Surface Print Subfunction.

3.4.14.1.3 Outputs

a. Operator prompts

b. Radar type flag

c. Antenna height

3.4.14.2 Surface Print Subfunction

3.4.14.2.1 Inputs

a. Radar type flag

b. Antenna height

3.4.14.2.2 Processing

This subfunction is called by the Surface Search Entry Subfunction. The classification, heading, location, and time are printed. The type of radar and antenna height are printed next. All of the U.S. ship table is printed first. Ship names and ranges are found by table look-up. The table entries are read from the mass storage device. The entries are arranged in five arrays in terms of antenna height: 80, 110, 140, 170, and 200 feet above the waterline. Each array contains large data for evaporation duct heights from 0 to 40 metres in 2m increments, plus surface-based ducts with heights of 150, 225, 200, 375, and 450m. If a surface-based duct exists, the range values for the closest duct height are referenced. Otherwise the range values corresponding to the evaporation duct height closest to the actual evaporation duct height in the environmental data set are referenced. The appropriate data for the ranges is found by interpolating the ranges for the antenna heights on either side of the operator entry. The same process is repeated for the Soviet ships. The classification is printed at the bottom of the page. Control is then transferred to the Options Function (3.4.10).

3.4.14.2.3 Outputs

Surface search radar range tables.

3.4.14.3 Set-Up Subfunction

3.4.14.3.1 Inputs

None

3.4.14.3.2 Processing

This subfunction is called by the Surface Search Entry Subfunction. The Set-Up Subfunction is used to initialize the default values of all variables and arrays. The lengths of character variables and dimensions for all arrays are established. All files are assigned symbolic names. Control returns to the calling subfunction.

3.4.14.3.3 Outputs

None

3.4.14.4 Error Subfunction

3.4.14.4.1 Inputs

None

3.4.14.4.2 Processing

This subfunction is referenced by any other subfunction to display a message to the operator indicating that an invalid or erroneous response has been made in response to a prompt. A mass storage device error also causes a reference to this subfunction.

In case of a mass storage device error, this subfunction causes a fatal error after informing the operator that a malfunction has occurred with the mass storage device. Any diagnostic information available is also displayed to the operator, then the processor is halted.

3.4.14.4.3 Outputs

Message displayed to operator.

3.5 Adaptation

This paragraph contains a description of the data base requirements with respect to the operational system environment, system parameters, and system capacities. Specifically, the libraries for ESM, environmental, historical, surface search, and system data are presented. In addition, estimates for processor storage capacity, interfacing timing rates, and the total processing time used by the program is established.

3.5.1 Data Base Requirements

There are five libraries that serve as a global data base for all the functions within IREPS:

a. ESM Data Set

b. Environmental Data Set

c. Historical Data Set

d. Surface Search Data Set

e. System Data Set

The field descriptions for each of these libraries is provided in Tables 3.5.1-1 through 3.5.1-5.

3.5.2 Estimate of Processor Storage Capacity

The processor must provide a minimum of 65K bytes of memory.

3.5.3 Interfacing Timing Rates

These transfer rates are listed in Table 3.3.2-1.

TABLE 3.5.1-1

ESM DATA SET

This library consists of two tables: The Soviet Emitter Table which is 41 items in length and the U.S. Emitter Table which is 54 items in length. For each emitter, the frequency and the maximum intercept range in nm are tabulated. The following emitters comprise each table.

SOVIET EMITTERS

KNIFE REST A	HEADLIGHT	KNIFE REST B
MUFF COB	CROSS BIRD	POP GROUP
SQUARE HEAD	BASS TILT	HIGH POLE
DRUM TILT	FAN SONG E MG	OWL SCREECH
TOP TROUGH	SQUARE TIE	BIG NET
SNOOP TRAY	TOP SAIL	PEEL GROUP
HIGH LUNE	HAWK SCREECH	SCOOP PAIR
TOP BOW	HEAD NET	SNOOP PLATE
SLIMNET	DONETS	LOW SIEVE
DONETS-2	BALL END	POT HEAD
HIGH SIEVE	LOW TROUGH	FRONT DOOR
SUN VISOR	TRAP DOOR	NEPTUNE
STRUT PAIR	DON KAY	STRUT CURVE
DON/DON-2		FAN SONG E MT

U.S. EMITTERS

SPS-43A	SPS-29	SPS-37
SPS-37A	SPS-32	SPS-40
SPS-49	IFF INT	TACAN
SPS-39	SPS-42	SPS-48
SPS-52	MK-26	SPS-39A
MK-35/MODO	SPS-33	SPS-30
SPN-43	SPN-6	SPN-10
SPG-49 ACQ	SPG-51	MK-37
BPS-5, 9, 11-15	MK-13	MK-34
SPG-53A	MK-68	SPG-34
SPG-50	SPQ-9A	MK-25/MOD 3
MK-35/MOD 2	MK-56	MK-25/MOD 2
MK-87	SPN-35	SPS-46
SPS-53	CPR 1500	CPR 2900
LN 66	RAYTHEON 2502	RAYTHEON 2840
RAYTHEON 1900	DECCA 202	DECCA 914
HEL-H 18/9	SPS-55	SPN-12
MK-115	SPG-53B	SPN-41
SPS-10		

TABLE 3.5.1-2

ENVIRONMENTAL DATA SET

This data set consists of 17 variables and 7 arrays. All arrays are 30 items long. See also 3.4.7.

VARIABLES

Name	Units	Type	Range
Sequence	N/A	Integer	1 to 16 Characters
Name	N/A	ASCII	1 to 24 Characters
Location	N/A	ASCII	1 to 24 Characters
Time	N/A	ASCII	1 to 24 Characters
Type	N/A	ASCII	1 Character
Height	N/A	ASCII	1 Character
Evaporation Duct Parameters Flag	N/A	ASCII	1 Character
WMO Height	N/A	ASCII	5 Characters
Wind Speed	m/s	Real	*
Sea Temperature	°C	Real	*
Air Temperature	°C	Real	*
Relative Humidity	%	Real	*
Height Zero	m	Real	*
Pressure Zero	mb	Real	*
Maximum Number of Items in Array	N/A	Integer	1 to 30
Delta	m	Real	*
Change Flag	N/A	Integer	0 to 1

* Real number range of the computer

TABLE 3.5.1-2 Con't

ENVIRONMENTAL DATA SET

ARRAYS

Name	Units	Type	Range
WMO Code Groups	N/A	ASCII	10 Characters
Pressure	mb	Real	*
Temperature	°C	Real	*
Relative Humidity	%	Real	*
Height	m	Real	*
M Units	M Units	Real	*
N Units	N Units	Real	*

* Real number range of the computer

Table 3.5.1-3

Historical Data Set

This data set consists of 440 records. The records are grouped into two sets of readings. Records 1 through 397 are Radiosonde Station Data and records 398 through 440 are Surface Station Observation Data. The fields for each type of record are described below.

Radiosonde Station Data

Field	Units	Type	Range
Identification	N/A	ASCII	5 Characters
Ocean Area (See Table 3.4.5-1)	N/A	ASCII	1 Character
Latitude	Degrees	Integer	-90 to 90
Longitude	Degrees	Integer	-180 to 180
Station Height	ft	Integer	0 to 255
GMT night soundings taken	Hr/Min	Integer	0 to 23, 0 to 59
GMT day soundings taken	Hr/Min	Integer	0 to 23, 0 to 59
Median Surface N Units			
Winter	N Units	Integer	0 to 127.5
Spring	N Units	Integer	0 to 127.5
Summer	N Units	Integer	0 to 127.5
Autumn	N units	Integer	0 to 127.5
Median M Unit Gradient From Surface to 1000 m			
Winter	M Units/km	Integer	0 to 255
Spring	M Units/km	Integer	0 to 255
Summer	M Units/km	Integer	0 to 255
Autumn	M Units/km	Integer	0 to 255
Median M Unit Gradient Station to Inflection Point for Surface Ducts			
Winter	M Units/km	Integer	0 to 255
Spring	M Units/km	Integer	0 to 255
Summer	M Units/km	Integer	0 to 255
Autumn	M Units/km	Integer	0 to 255
Median Inflection Point Above Station for Surface Ducts			
Winter	m	Integer	0 to 255
Spring	m	Integer	0 to 255
Summer	m	Integer	0 to 255
Autumn	m	Integer	0 to 255

Median Thickness for Surface Ducts			
Winter	m	Integer	0 to 255
Spring	m	Integer	0 to 255
Summer	m	Integer	0 to 255
Autumn	m	Integer	0 to 255
Median M Unit Deficit for Surface Based Ducts			
Winter	M Units	Integer	0 to 255
Spring	M Units	Integer	0 to 255
Summer	M Units	Integer	0 to 255
Autumn	M Units	Integer	0 to 255
Median Trapping Frequency for Surface Ducts			
Winter	MHz	Integer	0 to 255
Spring	MHz	Integer	0 to 255
Summer	MHz	Integer	0 to 255
Autumn	MHz	Integer	0 to 255
Percent Occurrence of Surface Duct in Daytime			
Winter	%	Integer	0 to 100
Spring	%	Integer	0 to 100
Summer	%	Integer	0 to 100
Autumn	%	Integer	0 to 100
Percent Occurrence of Surface Duct at Night			
Winter	%	Integer	0 to 100
Spring	%	Integer	0 to 100
Summer	%	Integer	0 to 100
Autumn	%	Integer	0 to 100
Median M Unit Gradient Below Elevated Duct Inflection Point			
Winter	M Units/km	Integer	0 to 255
Spring	M Units/km	Integer	0 to 255
Summer	M Units/km	Integer	0 to 255
Autumn	M Units/km	Integer	0 to 255
Median Height of Elevated Duct Inflection Point Above Station			
Winter	m	Integer	0 to 255
Spring	m	Integer	0 to 255
Summer	m	Integer	0 to 255
Autumn	m	Integer	0 to 255
Median Thickness of Elevated Duct			
Winter	m	Integer	0 to 255
Spring	m	Integer	0 to 255
Summer	m	Integer	0 to 255
Autumn	m	Integer	0 to 255

Median M Unit Deficit for Elevated Ducts			
Winter	m	Integer	0 to 255
Spring	m	Integer	0 to 255
Summer	m	Integer	0 to 255
Autumn	m	Integer	0 to 255
Median Trapping Frequency For Elevated Duct			
Winter	MHz	Integer	0 to 255
Spring	MHz	Integer	0 to 255
Summer	MHz	Integer	0 to 255
Autumn	MHz	Integer	0 to 255
Percent Occurrence of Elevated Duct in Daytime			
Winter	%	Integer	0 to 100
Spring	%	Integer	0 to 100
Summer	%	Integer	0 to 100
Autumn	%	Integer	0 to 100
Percent Occurrence of Elevated Duct at Night			
Winter	%	Integer	0 to 100
Spring	%	Integer	0 to 100
Summer	%	Integer	0 to 100
Autumn	%	Integer	0 to 100
Probability of More Than One Elevated Duct			
Winter	%	Integer	0 to 0.0255
Spring	%	Integer	0 to 0.0255
Summer	%	Integer	0 to 0.0255
Autumn	%	Integer	0 to 0.0255
Probability of Surface Duct And Elevated Duct			
Winter	%	Integer	0 to 0.0255
Spring	%	Integer	0 to 0.0255
Summer	%	Integer	0 to 0.0255
Autumn	%	Integer	0 to 0.0255

Surface Station Observation Data

Evaporation Duct Histogram in Percent Occurrence			
Winter Day			
0 to 10 ft	%	Integer	0 to 100
10 to 20 ft	%	Integer	0 to 100
20 to 30 ft	%	Integer	0 to 100
30 to 40 ft	%	Integer	0 to 100
40 to 50 ft	%	Integer	0 to 100
50 to 60 ft	%	Integer	0 to 100
70 to 80 ft	%	Integer	0 to 100
80 to 90 ft	%	Integer	0 to 100
90 to 100 ft	%	Integer	0 to 100
Above 100 ft	%	Integer	0 to 100
Undefined	%	Integer	0 to 100
Mean Duct Height	m	Integer	0 to 255
Winter Day			

Winter Night			
0 to 10 ft	%	Integer	0 to 100
10 to 20 ft	%	Integer	0 to 100
20 to 30 ft	%	Integer	0 to 100
30 to 40 ft	%	Integer	0 to 100
40 to 50 ft	%	Integer	0 to 100
50 to 60 ft	%	Integer	0 to 100
60 to 70 ft	%	Integer	0 to 100
70 to 80 ft	%	Integer	0 to 100
80 to 90 ft	%	Integer	0 to 100
90 to 100 ft	%	Integer	0 to 100
Undefined	%	Integer	0 to 100
Mean Duct Height Winter Night	m	Integer	0 to 255
Spring Day			
0 to 10 ft	%	Integer	0 to 100
10 to 20 ft	%	Integer	0 to 100
20 to 30 ft	%	Integer	0 to 100
30 to 40 ft	%	Integer	0 to 100
40 to 50 ft	%	Integer	0 to 100
50 to 60 ft	%	Integer	0 to 100
60 to 70 ft	%	Integer	0 to 100
70 to 80 ft	%	Integer	0 to 100
80 to 90 ft	%	Integer	0 to 100
90 to 100 ft	%	Integer	0 to 100
Above 100 ft	%	Integer	0 to 100
Undefined	%	Integer	0 to 100
Mean Duct Height Spring Day	m	Integer	0 to 255
Spring Night			
0 to 10 ft	%	Integer	0 to 100
10 to 20 ft	%	Integer	0 to 100
20 to 30 ft	%	Integer	0 to 100
30 to 40 ft	%	Integer	0 to 100
40 to 50 ft	%	Integer	0 to 100
50 to 60 ft	%	Integer	0 to 100
60 to 70 ft	%	Integer	0 to 100
70 to 80 ft	%	Integer	0 to 100
80 to 90 ft	%	Integer	0 to 100
90 to 100 ft	%	Integer	0 to 100
Above 100 ft	%	Integer	0 to 100
Undefined	%	Integer	0 to 100
Mean Duct Height Spring Night	m	Integer	0 to 255

Summer Day			
0 to 10 ft	%	Integer	0 to 100
10 to 20 ft	%	Integer	0 to 100
20 to 30 ft	%	Integer	0 to 100
30 to 40 ft	%	Integer	0 to 100
40 to 50 ft	%	Integer	0 to 100
50 to 60 ft	%	Integer	0 to 100
60 to 70 ft	%	Integer	0 to 100
70 to 80 ft	%	Integer	0 to 100
80 to 90 ft	%	Integer	0 to 100
90 to 100 ft	%	Integer	0 to 100
Above 100 ft	%	Integer	0 to 100
Undefined	%	Integer	0 to 100
Mean Duct Height Summer Day	m	Integer	0 to 255
Summer Night			
0 to 10 ft	%	Integer	0 to 100
10 to 20 ft	%	Integer	0 to 100
20 to 30 ft	%	Integer	0 to 100
30 to 40 ft	%	Integer	0 to 100
40 to 50 ft	%	Integer	0 to 100
50 to 60 ft	%	Integer	0 to 100
60 to 70 ft	%	Integer	0 to 100
70 to 80 ft	%	Integer	0 to 100
80 to 90 ft	%	Integer	0 to 100
90 to 100 ft	%	Integer	0 to 100
Above 100 ft	%	Integer	0 to 100
Indefined	%	Integer	0 to 100
Mean Duct Height Summer Night	m	Integer	0 to 255
Autumn Day			
0 to 10 ft	%	Integer	0 to 100
10 to 20 ft	%	Integer	0 to 100
20 to 30 ft	%	Integer	0 to 100
30 to 40 ft	%	Integer	0 to 100
40 to 50 ft	%	Integer	0 to 100
50 to 60 ft	%	Integer	0 to 100
60 to 70 ft	%	Integer	0 to 100
70 to 80 ft	%	Integer	0 to 100
80 to 90 ft	%	Integer	0 to 100
90 to 100 ft	%	Integer	0 to 100
Above 100 ft	%	Integer	0 to 100
Undefined	%	Integer	0 to 100
Mean Duct Height Autumn Day	m	Integer	0 to 255

Autumn Night			
0 to 10 ft	%	Integer	0 to 100
10 to 20 ft	%	Integer	0 to 100
20 to 30 ft	%	Integer	0 to 100
30 to 40 ft	%	Integer	0 to 100
40 to 50 ft	%	Integer	0 to 100
50 to 60 ft	%	Integer	0 to 100
60 to 70 ft	%	Integer	0 to 100
70 to 80 ft	%	Integer	0 to 100
80 to 90 ft	%	Integer	0 to 100
90 to 100 ft	%	Integer	0 to 100
Above 100 ft	%	Integer	0 to 100
Undefined	%	Integer	0 to 100
Mean Duct Height Autumn Night	m	Integer	0 to 255
Mean Wind Speed			
Winter Day	kts	Integer	0 to 255
Winter Night	kts	Integer	0 to 255
Spring Day	kts	Integer	0 to 255
Spring Night	kts	Integer	0 to 255
Summer Day	kts	Integer	0 to 255
Summer Night	kts	Integer	0 to 255
Autumn Day	kts	Integer	0 to 255
Autumn Night	kts	Integer	0 to 255

TABLE 3.5.1-4

SURFACE SEARCH DATA SET

This library consists of two tables: The Soviet Ship Type/Class Table which is 11 items in length and the U.S. Ship Type/Class Table which is 13 items in length. For each ship class the minimum, maximum, and average detection range in nm for 26 different environmental conditions are stored for antenna heights of 80, 110, 140, 170, and 200 ft above the water line. The following ship types/classes comprise each table.

SOVIET SHIPS

KIEV CLASS
MOSKVA CLASS
CLG
CG/CC/CA
DD/DDG
FRIGATE
CORVETTE
OSA/STENKA CLASS
PRIMORYE CLASS AGI
LENTRA CLASS AGI
OKEAN CLASS AGI

U.S. SHIPS

CV/CVN
CG/CGN
DD/DDG
FF/FFG
LCC
LHA
LPH
LKA
LPD
LSD
LST
AE/AF
AO/AOE/AOR

TABLE 3.5.1-5

COVER OR LOSS SYSTEM DATA SETS

All arrays in this library are 32 items in length.

Name	Units	Type	Range
Radar Name	N/A	ASCII	1 to 24 Characters
Display Type Flag	N/A	ASCII	1 Character
Platform Flag	N/A	ASCII	1 Character
Antenna Height	m	Real	*
Frequency	MHz	Real	*
Free Space Range	km	Real	*
Antenna Type	N/A	ASCII	1 Character
Beamwidth	Degrees	Real	*
Elevation Angle	Degrees	Real	*
Security	N/A	ASCII	1 Character
Label	N/A	ASCII	1 to 160 Characters

* Real number range of the computer

3.5.4 Total Processing Time Used by the Program

Refer to 3.2.1.

APPENDIX

System Variables and Arrays

(Not Contained In Libraries)

Ae - Effective earth radius in km

Antfac - Antenna factor

BW - Antenna vertical beamwidth in degrees

Difac - Non-range dependent loss in the diffraction region in dB

Div - Divergence factor

Dmdh - Array containing 10^{-3} times the change in modified refractivity with height for each layer

f - Frequency in MHz

Fsterm - Non-range dependent portion of the free space path loss in dB

$\overline{h}$ - Rms ocean wave height in metres

Hmax - Maximum height of plot in metres

Hmrs - Array containing the height at which each layer starts in metres

Ht - The transmitter or radar antenna height in metres

Hr - The target or receiving antenna height in metres

K - Effective earth radius factor

Patfac - Antenna pattern factor for a given ray

Rmax - Maximum range of plot in km

Rmin - Minimum range of plot in km

Ruf - Surface roughness factor

Twodm - Array containing 2 x 10^{-6} times the change in refractivity of each layer

α - Launch angle of the ray in radians

α_c - Launch angle below which no rays are trapped in the duct in radians

α_d - Launch angle above which no rays are trapped in the duct in radians

α_r - Minimum angle below which all rays are reflected in radians

γ - Angular distance to the reflection point for a grazing angle of ψ in radians

δ - Evaporation duct height in metres

ψ - Limiting grazing angle of the optical region in radians

DAT
FILM