Technical Document 1874
August 1990

Integrated Refractive Effects Prediction System (IREPS) User's Manual

Revision PC-2.0

W. L. Patterson

NAVAL OCEAN SYSTEMS CENTER
San Diego, California 92152-5000

J. D. FONTANA, CAPT, USN   R. M. HILLYER
Commander   Technical Director

ADMINISTRATIVE INFORMATION

This Integrated Refractive Effects Prediction System was designed and developed by the Tropospheric Branch, Code 543, of the Naval Ocean Systems Center, San Diego, CA 92152-5000. Manufacture, use, or sale of IREPS is covered by U.S. Patent 4,125,892.

CONTENTS

CONTENTS (continued)

FIGURES

CONTENTS (continued)

v

1.0 INTRODUCTION

1.1 PURPOSE

The purpose of this manual is to introduce you to the contents and operation of the Integrated Refractive Effects Prediction System, Personal Computer version 2.0 (IREPS PC-2.0).

IREPS PC-2.0 is an upgrade to IREPS PC-1.0, released in March 1989. IREPS PC-2.0 has a completely restructured file management system, a new screen-handling system which supports the use of a mouse, and an automatic product-generation mode, called AUTOMODE.

For a complete discussion of the basic principles of electromagnetic radiation, its use in object-detection systems such as radio detection and ranging (RADAR) and forward looking infrared (FLIR), the effects of the atmosphere on electromagnetic (EM) wave propagation, and guidelines in the interpretation and effective use of EM propagation products available from IREPS, refer to Naval Ocean Systems Center (NOSC) Technical Document 1369, "Effective Use of the Electromagnetic Products of TESS and IREPS." This technical document may be obtained from NOSC at the address listed in section 2.2.

1.2 HISTORICAL DEVELOPMENT

The IREPS software has been developed at NOSC to provide a shipboard environmental data processing and display capability for the comprehensive assessment of refractive effects upon naval surveillance, communications, electronic warfare, and weapon-guidance systems. IREPS revisions 1.0 through 2.2 were hosted on the Hewlett-Packard (HP) 9845 series of desktop computers. IREPS revision 3.0 was hosted on the HP 9000 series computer. IREPS revisions 1.0 through 3.0 use the HP BASIC computer language.

The assessment products of IREPS have been transitioned into the Tactical Environmental Support System (TESS) and the Geophysical Fleet Mission Program Library (GFMPL), both currently operational upon all CV/CVNs, LPH/LHAs, and other afloat and ashore commands, and into the Joint Operational Tactical System (JOTS), operational upon most ships of the U.S. Navy Fleet. Both TESS and GFMPL were completely new development efforts based on the FORTRAN-77 computer language, while the first versions of JOTS incorporated large amounts of original IREPS HP-BASIC coding.

Under a separate development effort, IREPS revision 2.1 was translated from the HP-BASIC code into FORTRAN-77 to support the NOSC High-Frequency Propagation Forecast Terminal System (Advanced PROPHET). IREPS PC-1.0 was a rehosting of a portion of the Advanced PROPHET software, bringing the IREPS product standards up to those of IREPS revision 3.0 on IBM PC-compatible computers. IREPS PC-2.0 screen- and file-handling routines are now written in the C programming language, with the mathematical calculations still made by using FORTRAN. The IREPS PC development efforts have nothing in common with the TESS and GFMPL development efforts.

IREPS PC-2.0 will work only on IBM-compatible computers that have either a CGA, EGA, or VGA graphics adapter. The summary, cover, and loss products of IREPS PC-2.0 have been tested and found to match the equivalent IREPS 3.0 products and the test specifications used by TESS and GFMPL. Graphics devices other than CGA or EGA are not supported by IREPS PC-2.0.

The operation of personal computers is described within the appropriate manuals provided with each system. It is assumed that you have an elementary knowledge of MS-DOS, directory/file structure, and the execution of programs.

2.0 GETTING STARTED

2.1 HARDWARE REQUIREMENTS

You can run IREPS PC-2.0 on the IBM PC, Personal Computer AT, PC/XT, or 100-percent-compatible computers with a graphics capability (CGA, EGA, VGA). IREPS PC-2.0 requires MS-DOS release 2.0 or greater.

IREPS PC-2.0 is distributed on one double-sided, double-density, 5-1/4- or 3-1/2-inch flexible diskette and does not require an internal hard disk drive.

2.2 SOFTWARE SUPPORT

The IREPS PC-2.0 software will be maintained solely by NOSC. Discrepancies in IREPS PC-2.0 products, difficulties encountered while running the program, and questions concerning the use of other IREPS revisions upon other computers or in other programming languages should be directed to:

Commander
Naval Ocean Systems Center
Code 543
San Diego, CA 92152-5000

Autovon: 553-1428 Commercial: 619-553-1428
FAX: 619-553-1417
Electronic Mail: 543@nosc.mil

To help NOSC in providing technical support to IREPS PC-2.0 users, an ASCII file, REGISTER.DOC, is provided on each IREPS PC-2.0 distribution disk. This file contains a registration form which may be filled out and mailed to the above address. Registration of your IREPS PC-2.0 disk will insure your receipt of any future upgrades of the IREPS PC-2.0 software, newsletters, or technical supporting documentation. Please limit registration to one per physical location or working group. You may copy the IREPS PC-2.0 distribution disk freely and make it available to your co-workers.

2.3 SOFTWARE PRINTER DUMPERS

The IREPS PC-2.0 software itself does not have the ability to dump graphics to a printer. The graphics-dumping programs provided with IREPS PC-1.0 are *not* compatible with IREPS PC-2.0.

There are, however, many commercial graphics-dumping programs available. For CGA users, the GRAPHICS command supplied by IBM and other vendors will work with Epson-compatible printers. A very good graphics dump program that works with both CGA and EGA adapters and a wide variety of printers is GrafPlus, available from Jewell Technologies, Inc., 4740 44th Ave. SW, Suite 203, Seattle, WA 98116, (206) 937-1081, for a cost of approximately $50. A very good color graphics dump program is Pizazz Plus, available from Application Techniques, Inc., 10 Lomar Park Drive, Pepperell, MA 01463, (508) 433-5201.

Graphics dump programs such as GrafPlus or Pizazz are able to issue an optional form-feed command to the printer after a screen dump is completed. Other graphics dump programs may not have a form-feed option. To accommodate programs without a form-feed command, we have added a setting to IREPS PC-2.0 which will issue a form-feed command to the printer after a screen dump. See section 3.6.8 for additional information.

2.4 PROGRAM CONFIGURATION AND FILE STRUCTURE

IREPS PC-2.0 consists of one executable program file named IREPS.EXE. Environment and EM system data are stored within individual files, one file per environment or system, created at the time of data entry. The number of files which may be maintained is only limited by the amount of disk space available. The following is a description of the default file and directory conventions used within IREPS PC-2.0.

The current working (home) directory is defined as the directory from which the IREPS PC-2.0 program is executed. The program will sense the home directory upon initial execution. When you enter an environment or an EM system, you will be prompted for a file name. IREPS PC-2.0 uses the MS-DOS naming conventions, that is, a complete file name may be composed of an eight-character body, a period, and a three-character extension. Any of the following symbols and letters may be used within a file name:

A–Z   a–z   0–9 $ %   '   –   @   { }   -   '   !   #   ( )   &

After the environment or system data are entered and the option to SAVE is selected, the file will be stored within a subdirectory of the home directory. If the subdirectory does not exist, it will be created. Each data type will have its own subdirectory. Environmental files will be placed in a subdirectory named ENV. Systems for which a coverage diagram is desired will be stored within a subdirectory named COV. Systems for which a loss diagram is desired will be stored within a subdirectory named LOS. Systems for which a free-space range calculation is desired will be stored within a subdirectory named RAD. Recipes of automatic product generation will be stored within a subdirectory named AUT.

As stated above, this subdirectory structure is the default for IREPS PC-2.0. Within the IREPS PC-2.0 utilities options, you may specify an alternative directory structure from the home directory. For example, you may place the IREPS.EXE file within your DOS path, which will allow you to execute IREPS PC-2.0 from multiple home directories, or you may execute IREPS PC-2.0 from a hard disk, but access system files from a floppy diskette.

Upon initial program execution, the default screen foreground and background colors (7 and 0, respectively), the default directory structure (see above), the default security labels (none), the default global units (English), and an optional form-feed command after a graphics screen printing (No) will be written to a configuration file named IREPS.INI for future use in program operations. If you are executing IREPS PC-2.0 from multiple home directories via the DOS path, each home directory will have its own IREPS.INI file. This IREPS.INI file is an ASCII text file which may be edited with any text editing program exterior to the IREPS program. Section 3.6.7 will describe how to use the IREPS utilities option to change these default values and rewrite the IREPS.INI file.

2.5 PROGRAM EXECUTION AND COMMAND LINE ARGUMENTS

IREPS PC-2.0 may be executed by changing to the directory containing the IREPS.EXE file (the home directory) or to any directory if accessing IREPS PC-2.0 via the DOS path, typing IREPS, and pressing the <Enter> key. If the IREPS.INI file does not exist in the home directory, it will automatically be created. A number of optional command line arguments may be added to the name IREPS before pressing <Enter>:

a. *IREPS CGA.*   The default monitor is EGA. Execute IREPS PC-2.0 with the CGA command line argument if you do not have an EGA or VGA monitor.

b. *IREPS BW.*   The default screen is for color. The first line of the IREPS.INI file contains two numbers, a foreground color, and a background color.

3

The default is 7 (white foreground) and 0 (black background). Execute IREPS PC-2.0 with the BW command line argument for monochrome monitors.

c. *IREPS NOMOUSE.* The default is to use a mouse. Execute IREPS PC-2.0 with the NOMOUSE command line argument if a mouse is installed, but you wish to deactivate it.

d. *IREPS Hyy Vxx.* The default setting for vertical, yy, and horizontal, xx, mouse speed is yy=48 and xx=256. Decreasing the numbers will make the mouse more sensitive to movements.

2.6 DATA ENTRY METHODS

All data are input through the use of menu screens, file selection screens, or fill-in-the-blank input screens. Each screen contains one or more input fields. When a screen is presented, a highlight bar is positioned over the first available input field. Usually, this input field will contain a default input value. Pressing the <Enter> key at this point will cause the default value to be accepted as your choice. An input field type may be numerical with no limits or units, such as an item within a menu; numerical with limits and units, such as sea temperature; character without options, such as a date label or a file name; or character with options, such as transmitter antenna type.

From a menu screen, a menu item may be selected by pressing the number or character associated with it, by moving the highlight bar over it with the arrow keys and pressing the <Enter> key, or by using a mouse to move the highlight bar over it and "clicking" the left mouse button. Various special function keys, <F1> through <F10>, displayed at the bottom of the screen, will allow such functions as copying one file to another, deleting a file, or entering a new file.

From a file screen, a file name may be selected by moving the highlight bar over it with the arrow keys and pressing the <Enter> key, or by using a mouse to move the highlight bar over it and clicking the left mouse button.

From a fill-in-the-blank input screen, a numerical field with limits and units or character fields without options may be opened for input by moving the highlight bar over the desired field with the arrow keys or a mouse. The new value may then either be overtyped or a portion of the old value removed with the <Del> key and a new value typed. The overtype feature is inoperative when the cursor is in the last position of a numerical field. Therefore, any number in this last position must be removed with the <Del> key and retyped. Character fields with options may be entered by pressing the <space> bar or the <F9> Toggle Units/Values key, which will "toggle" a list of choices through the field. Pressing the <Enter> key after the field has been modified will close the field and the highlight bar will automatically move to the next input field. Simultaneously pressing the <Ctrl> and <Enter> keys will override any limits checking of an input value. WARNING! In some cases, such an "out-of-limits" value may cause erroneous results or in the extreme may cause IREPS PC-2.0 to abort.

While entering a numerical value which has associated units, you may press the <F9> Toggle Units/Values key to change the units. As the units change, however, so do the limits of input and a new numerical value may be required. For example, you may enter an air temperature value of 60 degrees with units of Fahrenheit. Changing the units to Celsius will now cause the value of 60 degrees to be beyond the valid input limits and a new value will have to be entered before you will be allowed to close the field. *No value conversions are performed when units are changed.*

4

3.0 IREPS PC-2.0 OPTIONS

Following a title page displaying the default directory structure and other information (Fig. 1), the IREPS PC-2.0 main options menu (Fig. 2) will be displayed. These options are used to obtain an IREPS PC-2.0 product or perform a major utility.

```
┌─────────────────────────────────────────────────────────────────┐
│        Integrated Refractive Effects Prediction System (IREPS)    │
│                                                                   │
│                   IREPS PC-2.00    01 July 1990                   │
│   MANUFACTURE, USE, OR SALE OF THIS PROGRAM IS COVERED BY U.S. PATENT 4,125,893 │
│            Naval Ocean Systems Center Code 543 San Diego, CA 92152-5000 │
│      Com: 619-553-1428 AV: 553-1428 Fax: 619-553-1417 email: 543@nosc.mil │
└─────────────────────────────────────────────────────────────────┘
```
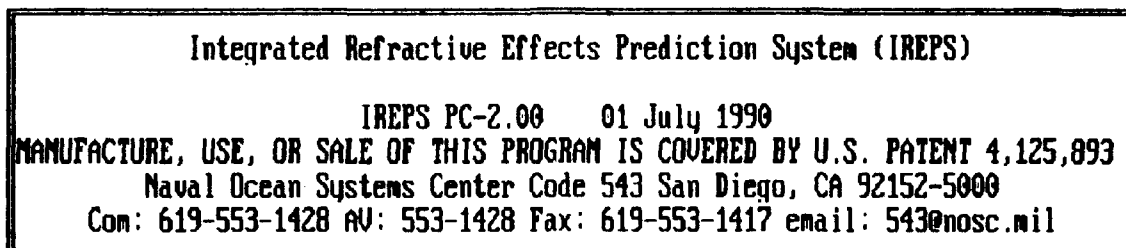
IREPS is a program that generates graphical products to assess the effects of the lower atmosphere on radar, communications, and ESM intercept performance based on user-entered meteorological data.

User data files are stored in the following directories. If you want these paths changed, use the utilities option on the main menu.

```
Environmental Data Files --> C:\IREPS\ENV\
Cover System  Files ------> C:\IREPS\COV\
Loss System Files --------> C:\IREPS\LOS\
Radar System Files -------> C:\IREPS\RAD\
Automode Files -----------> C:\IREPS\AUT\
```

Press Enter to continue. █

Figure 1. IREPS PC-2.0 title page.

```
┌─────────────────────────────────────────────────┐
│                                                 │
│                 IREPS OPTIONS                   │
│             Environment: NOT SPECIFIED          │
│                                                 │
├─────────────────────────────────────────────────┤
│                                                 │
│   1█  Select/Enter Environmental Data           │
│   2   Propagation Conditions Summary            │
│   3   Coverage Display                          │
│   4   Loss Display                              │
│   5   Automode                                  │
│   6   Utilities and Editors                     │
│   Esc Exit from IREPS                           │
│                                                 │
└─────────────────────────────────────────────────┘
```
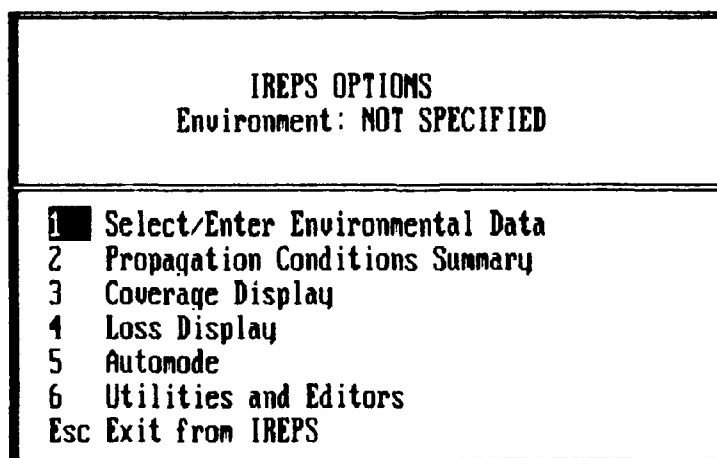
Figure 2. Screen display of the IREPS PC-2.0 options.

To exit IREPS PC-2.0 or to return to the main menu from any other menu, press the <Esc> key or click the right mouse button.

An IREPS PC-2.0 product consists of a mixture of alphanumeric labels and graphic displays which may be reproduced upon paper by using any available graphics dumping program (see section 2.3).

Note! The numerical models used to produce the IREPS PC-2.0 products make certain assumptions which will mandate limitations on their use. In order to insure the successful use of the products, you are urged to review these limitations as discussed in section 5.0.

A particular option may require you to enter data at the time of actual product generation. For example, IREPS PC-2.0 option 4 (Loss Display) will require you to enter a receiver or target height. Screen prompts will be provided as necessary to complete the product request. At the completion of each requested product, you will be presented with the IREPS PC-2.0 option menu for additional product selection, the performance of utility functions, or program termination.

3.1 OPTION 1—SELECT/ENTER ENVIRONMENTAL DATA

Normally, the first step in using IREPS PC-2.0 to assess refractive effects is to provide environmental data to the program. If you select an option which requires environmental data and none are specified, you will be notified of the requirement and the program will automatically present you with the Select/ Enter Environmental data option. Selecting an environmental data set before using the UTIL option is not required.

By selecting option 1, an environmental file name screen will be displayed. Figure 3 illustrates the format for this display. Select the desired file name by using the arrow keys or a mouse to highlight it and

```
┌─────────────────────────────────────────────────────────────────┐
│                    Environmental Data Files                       │
├─────────────────────────────────────────────────────────────────┤
│  ██████████   23-JAN.90    24-JAN.90    25-JAN.90     ENVIRO.EVP  │
│  ENVIRO.SBD   ENVIRO.STD   SOCAL..DEC   SOCAL.JUL     WESTPAC.89  │
│                                                                   │
│                                                                   │
│                                                                   │
│                                                                   │
│                                                                   │
│                                                                   │
│                                                                   │
│                                                                   │
│                                                                   │
│                                                                   │
│                                                                   │
│                                                                   │
└─────────────────────────────────────────────────────────────────┘
```

Esc-Main Menu   F5-New

Figure 3. Screen display of existing environmental data sets.

6

then press the <Enter> key or click the left mouse button. Once selected, the appropriate data will be entered into the program and you will be returned to the IREPS PC-2.0 option menu.

3.2 OPTION 2—PROPAGATION CONDITIONS SUMMARY

Figure 4 shows an example of a propagation-conditions summary. This product is used to show the existing refractive conditions for the location and time of the environmental data entered. In addition, the summary gives a plain-language narrative assessment of what effects may be expected on an EM system-independent basis.

The summary shows modified refractivity in M-units as a function of altitude. The presence and vertical extent of any ducts are shown by shaded areas on a vertical bar to the right of the refractivity profiles. The quantities of wind velocity and evaporation duct height are printed numerically. Printed to one side of the product are three categories, labeled SURFACE-TO-SURFACE, SURFACE-TO-AIR, and AIR-TO-AIR, in which brief statements occur concerning the general performance of EM systems.

You may use the propagation-conditions summary to assess the reliability of the environmental data. Rapid fluctuations in refractivity or unusually sharp gradients in refractivity, both of which may be caused by environmental input errors or improper environmental assessment methods, will become obvious by inspecting the modified refractivity profile. In addition, the refractivity profile may be inspected to insure meteorological consistency. For example, if a Foehn condition is known to exist, there should be an indication of a surface-based duct or a discussion of extended performance ranges within the narrative. The evaporation duct height should be inspected. Any evaporation duct height greater than 30 meters should immediately be suspect.

```
IREPS PC-2.00 *** PROPAGATION CONDITIONS SUMMARY ***   Location Label
                                                       Time Label

    **** SURFACE-TO-SURFACE ****
EXTENDED RANGES AT ALL FREQUENCIES      4K

    **** SURFACE-TO-AIR ****
EXTENDED RANGES      0 TO    300 M
POSSIBLE HOLES ABOVE    300 M          3K

    **** AIR-TO-AIR ****              M
EXTENDED RANGES      0 TO    300 M     E
POSSIBLE HOLES ABOVE    300 N          T   2K
                                       E
                                       R
                                       S
                                          1K


                                       0
                                          330   430   530   630   730   DUCTS
                                          MODIFIED REFRACTIVITY - M UNITS


                                          TRUE WIND SPEED =    .0 knots
    SFC REFRAC: 340.0 - SET SPS-48 TO 344    EVAPORATION DUCT HEIGHT =  13.0 M
```

Figure 4. Typical propagation-conditions summary.

7

3.3 OPTION 3—COVERAGE DISPLAY

Figure 5 is an example of a radar/radio coverage display product that shows area of coverage on a curved-earth, range-versus-height plot. The shaded area in the display corresponds to an area of expected detection, communication, or electronic surveillance measures (ESM) intercept for the specified EM system. Multiple shading densities may be employed, with various densities corresponding to variables such as target radar cross-section, probability of detection, or transmitter power.

```
IREPS PC-2.00        *** COVERAGE DISPLAY ***        Classification
                                                     Location Label
       50K                                           Time Label

H  40K                                               SYSTEM:        SPS-AA
E                                                    FREQ:        200.0 MHZ
I                                                    ANT HT:       100.0 FT
G  30K
H                                                    POLARIZATION:     HOR
T  20K                                               ANT TYPE:       SINX/X
                                                     VERT BW:       10.0 DEG
I  10K                                               ANT ELEV:       .0 DEG
N
                                                     MAX INS RNG:      N/A
F   0
E      0      40                                     FREE SPACE RANGE(S)
E              80                                    IN NAUTICAL MILES:
T                120                                    25.0     50.0
                                                       75.0    100.0
                       160
       RANGE IN NAUTICAL MILES              7 SHADED AREAS INDICATE
                                        200 AREAS OF DETECTION OR
                                            COMMUNICATION
300 m surface-based duct.  Free-space ranges based upon
radar cross-section of 0.1, 1., 10., and 100. sq meters
```

Figure 5. Typical coverage display for a surface-based EM system.

For airborne systems (Fig. 6), only one shading is employed and the degree of shading has no relationship to the signal level expected at a point. The lines (or rays), which are drawn on a dot-matrix display, often show some patterns or distinct lines within the contour. These are called moire patterns and result from the digital nature of the display. The ray drawing technique minimizes the number of rays plotted to limit the amount of time it takes to produce an airborne system coverage display and the ray spacing gives rise to the moire patterns.

In addition to the basic coverage display plot, this product also includes location and time labels for the environmental data set and a numeric listing of system parameters used in the generation of the product.

It is not the intent of the coverage model to calculate the maximum range for a given system, but rather to show the relative performance at different altitudes as affected by the environment. It is up to

8

you to insure that the free-space ranges (figures of merit) (section 3.6.4) being used are appropriate for the application at hand.

If a maximum unambiguous range (section 4.2.2) has been specified among the system parameters, the coverage display will be terminated at this range. This range cutoff may be seen in Fig. 6.

```
IREPS PC-2.00      *** COVERAGE DISPLAY ***        Classification
                                                   Location Label
     50K ┬                                         Time Label

 H   40K ┤                                         SYSTEM:        APS-XX
 E                                                 FREQ:          200.0 MHZ
 I                                                 ANT HT:        15000.0 FT
 G   30K ┤
 H                                                 POLARIZATION:      HOR
 T   20K ┤                                         ANT TYPE:          OMNI

 I   10K ┤
 N

 F    0  ┬                                         MAX INS RNG: 160.0 NM
 E       0        40                               FREE SPACE RANGE(S)
 E                      80                          IN NAUTICAL MILES:
 T                            120                       250.0

                                  160
         RANGE IN NAUTICAL MILES               SHADED AREAS INDICATE
                                          200  AREAS OF DETECTION OR
                                               COMMUNICATION
```
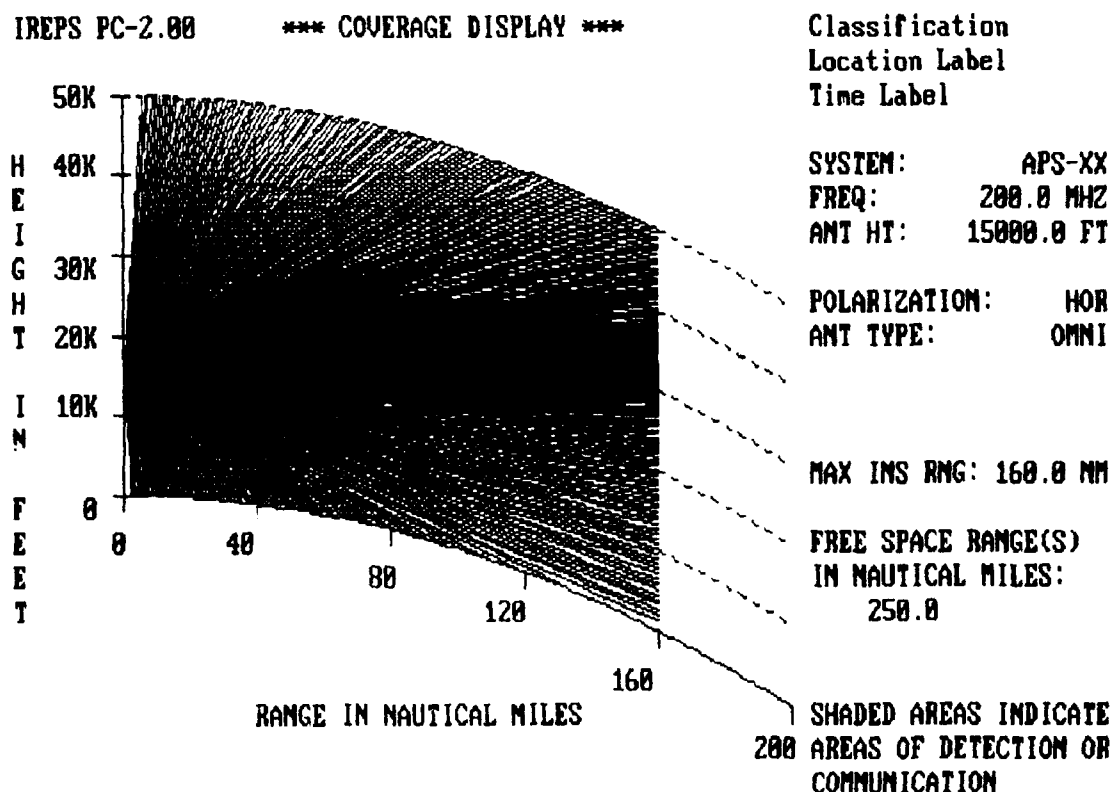
Free-space range based upon detection of a target with
a radar cross-section of 10,000 square meters

Figure 6. Typical coverage display for an airborne EM system.

3.4 OPTION 4—LOSS DISPLAY

The path-loss-versus-range display, as illustrated by Fig. 7, shows the energy loss along a path parallel to the earth's surface due to spreading, diffraction, scattering, and anomalous propagation. The horizontal dashed lines represent energy levels, or thresholds, necessary for radar detection, radio communication, ESM intercept, or other EM system function. The function is possible at all ranges with a path loss above the threshold (lower path loss). The function is not possible or improbable at all ranges with a path loss below the threshold (higher path loss). As with the coverage display, up to four threshold values (one for airborne systems) may be employed in the one path-loss display, with each threshold representing, for example, a different receiver sensitivity, transmitter power, probability of detection, target radar cross-section.

The use of the path-loss display is appropriate whenever a coverage display may be employed. In fact, the path-loss-versus-range display may be thought of as a horizontal slice of a coverage display. Figure 8 illustrates a path-loss display (for an aircraft target at 20,000 feet) and the corresponding coverage display

for a typical surface-based, omnidirectional UHF radiating antenna. The free-space range of the coverage display has been converted into a free-space path-loss threshold by using the utilities of section 3.6.4. The points A through E on the coverage display correspond to the the points A through E on the path-loss display, illustrating the interference pattern created by the phase difference of the direct-path and sea-surface reflected waves. The shaded lobes of the coverage display are represented by the portion of the path-loss curve above the path-loss threshold. The unshaded nulls of the coverage display are represented by the portion of the path-loss curve below the path-loss threshold.
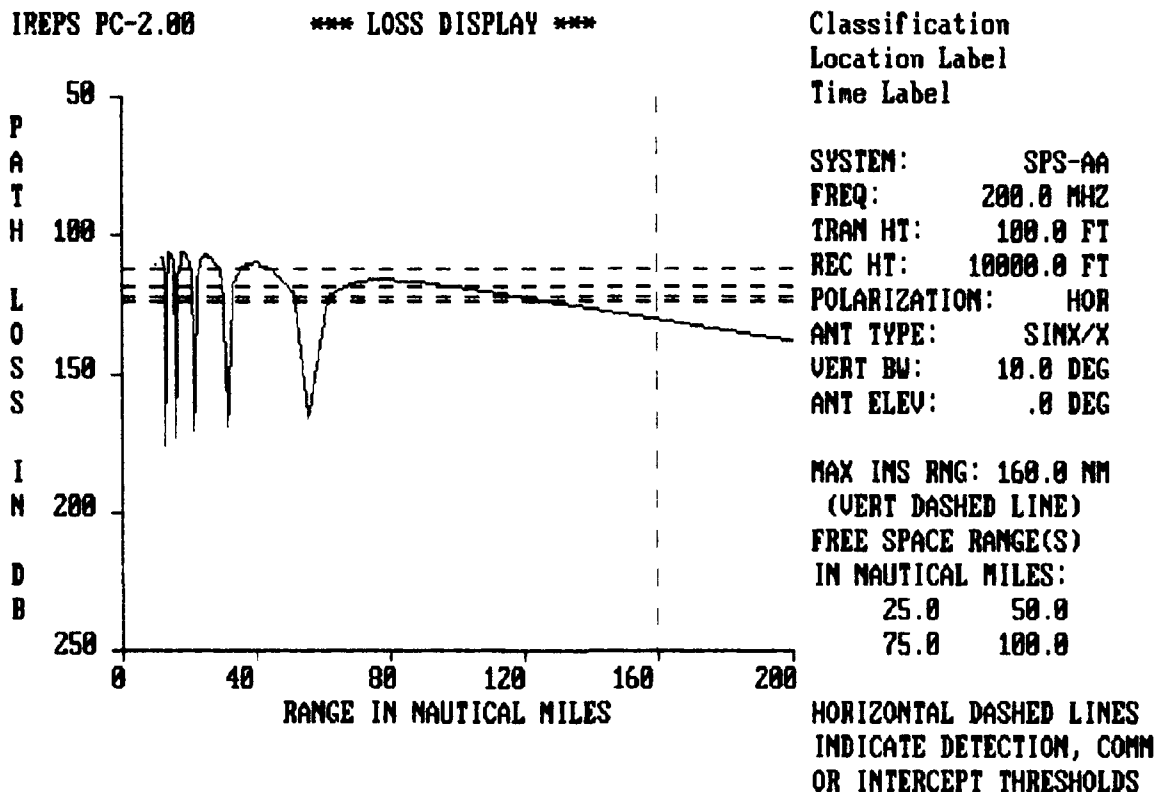

```
IREPS PC-2.00        *** LOSS DISPLAY ***        Classification
                                                 Location Label
      50 ┐                                    |   Time Label
P        │                                    |
A        │                                    :   SYSTEM:         SPS-AA
T        │                                    :   FREQ:        200.0 MHZ
H    100 ┤                                    :   TRAN HT:      100.0 FT
         │                                    :   REC HT:     10000.0 FT
L        │                                        POLARIZATION:    HOR
O        │                                        ANT TYPE:      SINX/X
S    150 ┤                                    :   VERT BW:      10.0 DEG
S        │                                    :   ANT ELEV:       .0 DEG
         │                                    |
I        │                                    |   MAX INS RNG: 160.0 NM
N    200 ┤                                    |    (VERT DASHED LINE)
         │                                    |   FREE SPACE RANGE(S)
D        │                                    |   IN NAUTICAL MILES:
B        │                                    |      25.0      50.0
     250 ┴──┬────┬────┬────┬────┬────┬─        75.0     100.0
         0     40    80   120   160   200
            RANGE IN NAUTICAL MILES          HORIZONTAL DASHED LINES
                                             INDICATE DETECTION, COMM
                                             OR INTERCEPT THRESHOLDS
300 m surface-based duct.  Free-space ranges based upon
radar cross-section of 0.1, 1., 10., and 100. sq meters
```

Figure 7. Example of path-loss-versus-range display.

Note that the aircraft symbols of Fig. 8 are both at a range of approximately 185 nmi from the transmitter. From the coverage display, the aircraft will be undetected since it is at a range, R (approximately 40 nmi), from a lobe (maximum) in the interference pattern. This range corresponds to the signal strength difference, ΔS (approximately 22 dB), of the path-loss display, where ΔS is the difference between the minimum signal strength necessary for detection and the actual signal strength at the target.

An example of a graphics drawing produced by the IREPS PC-2.0 program is also seen within Fig. 8. Note that within the coverage display, the interference pattern detail is smoothed beginning at the fourth lobe. That is, no further lobes or nulls are shown. Within the path-loss display, however, two additional lobes and nulls are shown. Beyond the sixth lobe of the path-loss display, only the level of minimum path loss is shown (the dots associated with the letter X). As the range scale of the path-loss display changes, the number of lobes plotted will change. You must be aware, therefore, that even though the illustrated path-loss curve is below the minimum path loss, signal fading may still be possible.
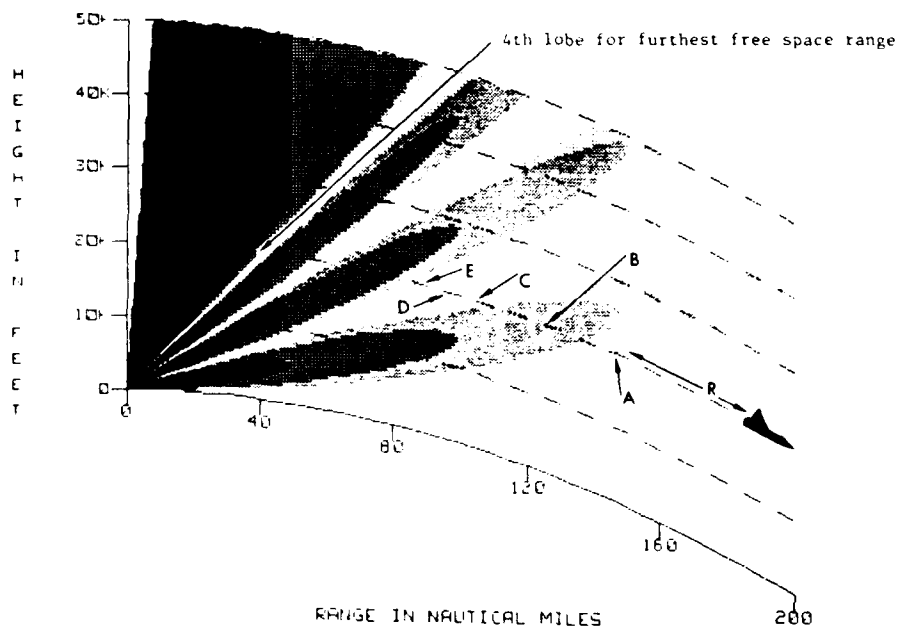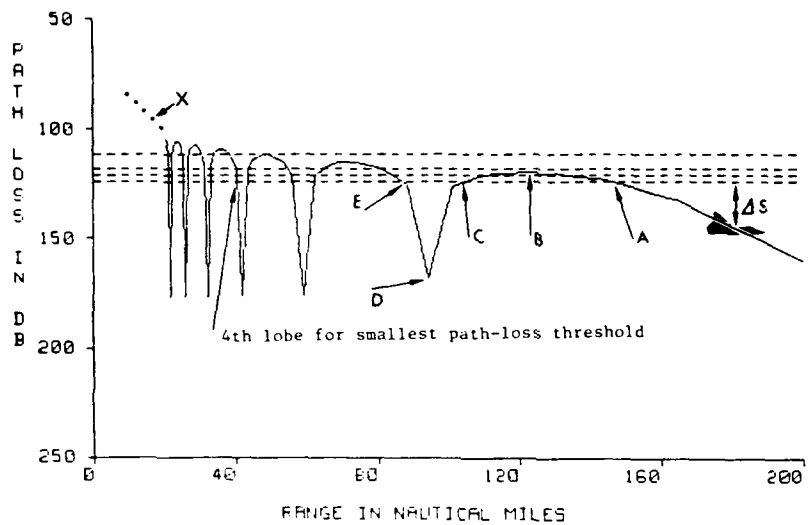
Figure 8. Path-loss display and corresponding coverage display.

11

3.5 OPTION 5—AUTOMODE

The selection of IREPS PC-2.0 option 5 will produce an automatic (hands off) generation of any and all IREPS PC-2.0 products, with multiple copies. Automode uses a recipe which you have previously defined. A detailed discussion of how to define the recipe may be found in section 4.7. This option becomes useful once the routine users of the IREPS PC-2.0 products, and the types of products they utilize, have been established. **Note!** Refer to sections 2.3 and 3.6.8 for a discussion of graphics screen dumping programs.

3.6 OPTION 6—UTILITIES AND EDITORS

The selection of IREPS PC-2.0 option 6 will access the utility and editor function menu, as illustrated in Fig. 9.

```
┌──────────────────────────────────────────────┐
│                                                │
│               UTILITY OPTIONS                  │
│                                                │
├──────────────────────────────────────────────┤
│  1  Print User Data Files                      │
│  2  Edit User Data Files                       │
│  3  List Current Environmental Data            │
│                                                │
│  4  Radar Free Space Detection Range Calculations │
│  5  Free Space Intercept Range Calculations    │
│  6  Surface Refractive Conditions              │
│                                                │
│  7  Change User Data File Paths                │
│  8  Change Default Units                        │
│  9  Change Classification Labels               │
│ Esc Main Menu                                  │
└──────────────────────────────────────────────┘
```
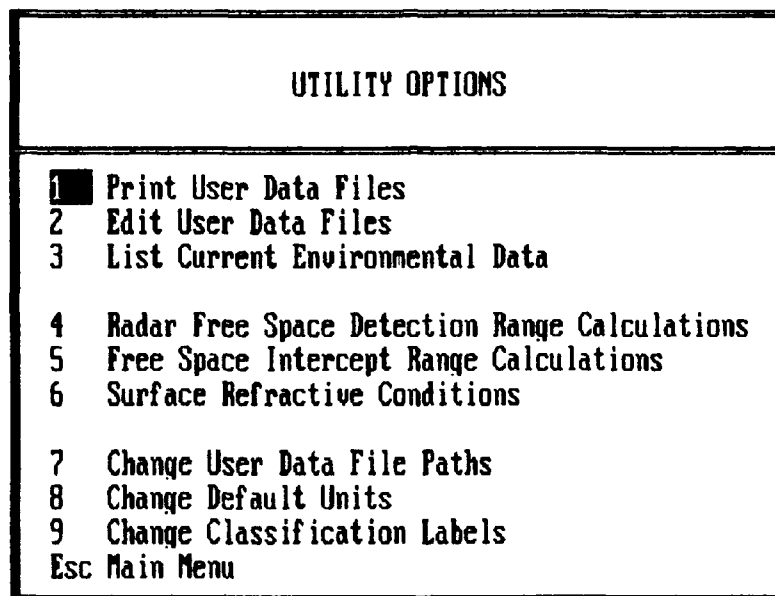
Figure 9. Screen display of the utility menu.

User data are defined as data entered by you, the operator of the IREPS PC-2.0 program. User data consists of EM system parameters, such as frequency and transmitter height, and environmental parameters, such as atmospheric pressure and wind speed. The PRINT, EDIT, or LIST utilities are used for the initial entry, display, editing, or deletion of previously entered user data.

As stated earlier, each user data set is stored in a separate file within a system directory (category) structure. When performing a print or edit function upon a data set, you will be presented with a menu of system categories from which to choose. For example, Fig. 10 illustrates the system category menu for the EDIT utility. By selecting a particular system category, you will be presented with a file name screen for the systems within that category. Figure 11, for example, shows a file name screen for coverage systems. After the desired file is selected, further screen displays will complete the utility.
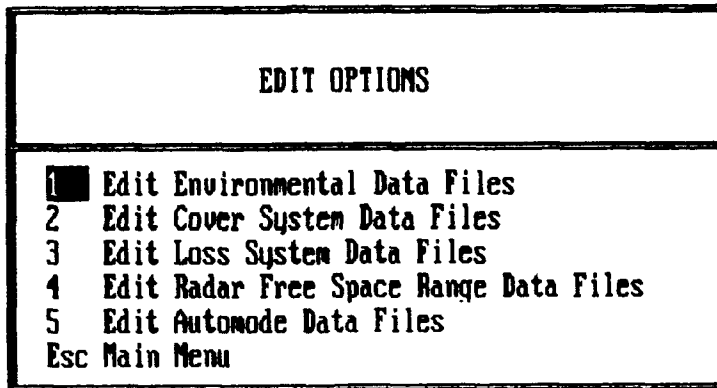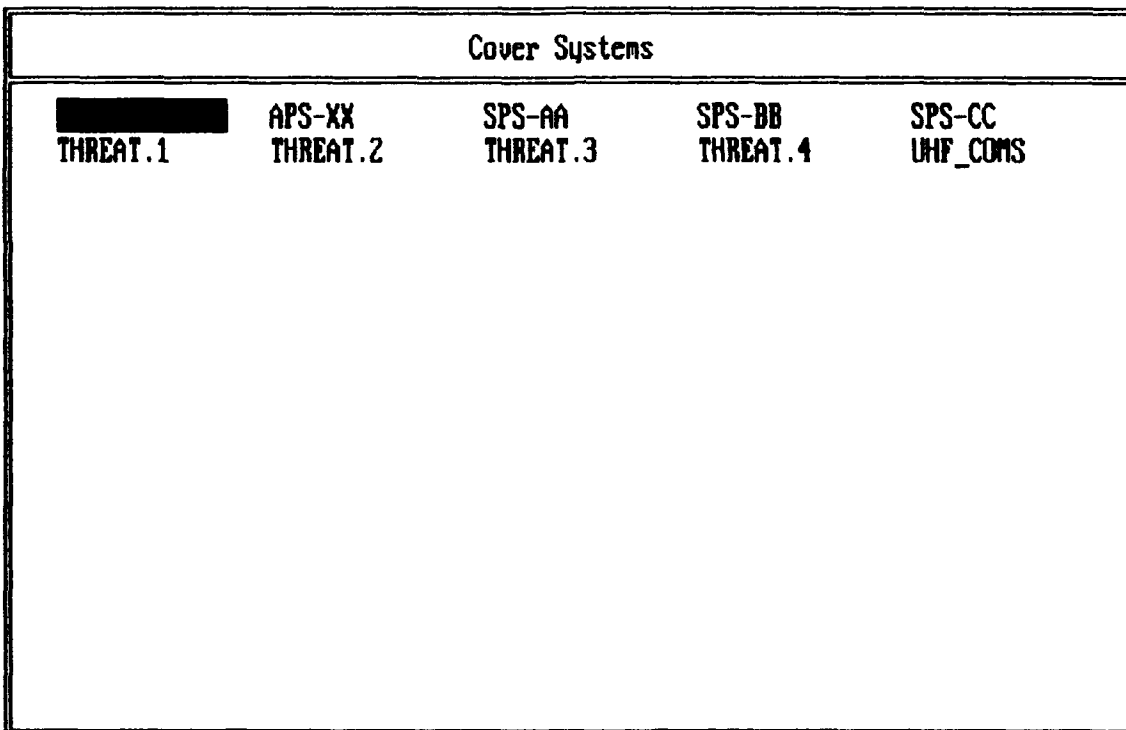
```
┌─────────────────────────────────────────────────┐
│                                                   │
│                 EDIT OPTIONS                      │
│                                                   │
├───────────────────────────────────────────────────┤
│  ▮  Edit Environmental Data Files                 │
│  2   Edit Cover System Data Files                 │
│  3   Edit Loss System Data Files                  │
│  4   Edit Radar Free Space Range Data Files       │
│  5   Edit Automode Data Files                     │
│  Esc Main Menu                                    │
└───────────────────────────────────────────────────┘
```

Figure 10. Screen display of the EDIT
utility system category menu.

```
┌─────────────────────────────────────────────────────────────┐
│                       Cover Systems                          │
├───────────────────────────────────────────────────────────────┤
│  ████████        APS-XX        SPS-AA        SPS-BB        SPS-CC │
│  THREAT.1        THREAT.2      THREAT.3      THREAT.4      UHF_COMS │
│                                                              │
│                                                              │
│                                                              │
│                                                              │
│                                                              │
│                                                              │
│                                                              │
│                                                              │
│                                                              │
│                                                              │
└───────────────────────────────────────────────────────────────┘
```

Esc-Main Menu   F4-Delete   F5-New

Figure 11. Screen display of existing cover data files.

3.6.1 Utility Option 1—Print User Data Files

The listing utility may be used to obtain a hard copy (paper) listing of any user data for archival or transfer purposes. For example, should you discover an unresolved software problem within the IREPS PC-2.0 code, the user data involved in the error may be forwarded to NOSC to aid in software trouble shooting.

3.6.2 Utility Option 2—Edit User Data Files

The editing utility serves as the user data input, alteration, or deletion point for the IREPS PC-2.0 program. Upon selecting a file as defined above, you will be presented with an input screen. For example, Fig. 12 illustrates the input screen for a coverage system. A detailed discussion of all input parameters is given in section 4.2.

```
┌──────────────────────────────────────────────────────────────────┐
│                             SPS-AA                                 │
├──────────────────────────────────────────────────────────────────┤
│     Maximum height (3000 to 100000): 50000  feet                   │
│     Maximum range    (0 to 500): 200     nautical miles            │
│     Type of platform: SURFACE                                      │
│     Antenna height   (3 to 300): 100     feet                      │
│     Frequency   (100 to 20000): 200    MHz                         │
│     Polarization: HORIZONTAL                                       │
│     Free space range(s)                                            │
│     25    nm 50    nm 75    nm 100    nm                            │
│     Maximum instrumented range (0=NA)  (0 to 500): 0     nautical miles │
│     Antenna type: SINX/X                                           │
│     Vertical beamwidth (.5 to 45): 10    deg                       │
│     Antenna elevation angle (-10 to 10): 0    deg                  │
│     Security classification: Classification                        │
│     Label one: 300 m surface-based duct. Free-space ranges based upon │
│     Label two: radar cross-section of 0.1, 1., 10., and 100. sq meters │
└──────────────────────────────────────────────────────────────────┘
```

F1-Save & Exit   F2-Exit W/O Save   F3-Print   F9-Toggle Units/Values   F10-Copy

Figure 12. Sample cover system input screen.

14

3.6.3 Utility Option 3—List Current Environmental Data

Assuming you have entered or selected an environmental data set, utility option 3 will produce a listing of this environmental data, as illustrated in Fig. 13. This example environmental data set was generated from the World Meteorological Organization (WMO) message of section 4.1.4.

The listing is used primarily for checking numerical values entered from IREPS PC-2.0 option 1 (Select/Enter Environmental Data). This listing may also serve as an archive for environmental data sets for future use. In addition to a display of the input data (e.g., pressure, temperature, M-units), values of dew point depression, N-unit gradients, and refractive conditions are calculated and displayed. If the original data are input via WMO code, the phrase "derived from WMO code" will appear immediately below the listing title. The bottom line of the list also displays the surface refractive conditions and a setting for the SPS-48 height-finder radar. This SPS-48 setting adjusts the surface refractivity value, which is used, in turn, to properly account for refractive effects in its calculations of elevation angle and height.

3.6.4 Utility Option 4—Radar Free-Space Detection Range

For the assessment of a radar's performance, *the most important factor to consider is the radar's free-space detection range*, or in other words, the range at which a specific target may be detected in an isotropic, homogeneous, lossless environment. This range may also be thought of as the maximum range at which a radar can detect a specified target when both the radar and the target are far removed from any influence of the earth or its atmosphere, such as in "free space." This range serves as an optimum range (or figure of merit) for a particular radar-target combination and allows for a comparison with nonstandard refractive conditions.

The most accurate method of establishing the free-space range is by observing the actual maximum detection range of known targets at angles above a few degrees from the horizontal, where the effects of refraction are minimized. For surface-based 2-D air-search radar systems, the free-space detection range is one-half the maximum observed range at high altitudes because of the influences of the interference region. For surface-based height-finder and all airborne radar systems, the free-space detection range is the maximum observed range at high altitudes.

If this a priori knowledge is lacking, the free-space range may be calculated based on other known engineering parameters, such as transmitter power and antenna gains. As with the PRINT, EDIT, and LIST utilities, utility option 4 will present a file screen similar to that of Fig. 11 and an input screen (Fig. 14). The calculation of free-space range involves a number of uncertainties and assumptions, often leading to an overly optimistic range. Again, you are cautioned to use the most accurate data available, taking into account the exact operating characteristics of the system. For example, the free-space range of a radar operating with its sensitivity time constant (STC) function off will not be the same as that of a radar operating with its STC function on. This utility and the free-space intercept range utility discussed below will provide the free-space value in nautical miles, kilometers, and decibels.

*** ENVIRONMENTAL DATA LIST *** DERIVED FROM WMO DATA

LOCATION: 23.2N - 061.3E
DATE/TIME: 23rd day - 2300Z
TRUE WIND SPEED= 5.1 m/sec
SURFACE PRESSURE= 1009.0 MB
RADIOSONDE LAUNCH HEIGHT= 9.0 M   EVAPORATION DUCT HEIGHT= 13.0 M

	PRESS	TEMP	RH	DEW PT					
LEVEL	(MB)	(C)	(%)	DEP(C)	METERS	N UNITS	N/KM	M UNITS	CONDITION
1	1009.0	25.6	77.2	4.2	9.0	368.3	-187.1	369.7	TRAP
2	1000.0	25.2	44.3	13.0	88.0	319.8	-45.3	333.6	SUPER
3	986.0	26.4	32.0	18.1	212.0	301.4	-13.5	334.6	NORMAL
4	850.0	19.0	19.2	24.1	1502.2	244.2	-7.1	480.0	NORMAL
5	746.0	8.8	24.8	19.1	2601.4	218.5	-4.7	626.8	NORMAL
6	700.0	5.8	35.7	14.2	3125.0	210.5	-8.1	701.0	NORMAL
7	630.0	.4	28.8	16.2	3978.8	187.7	-2.3	812.2	NORMAL
8	564.0	-6.7	87.0	1.8	4855.4	181.1	-8.5	943.2	NORMAL
9	533.0	-9.3	74.9	3.6	5295.4	168.8	-5.4	1000.0	NORMAL
10	500.0	-13.3	89.1	1.4	5786.3	160.1	-4.8	1068.3	NORMAL
11	487.0	-15.5	100.0	.0	5986.3	156.9	-24.8	1096.5	SUPER

*** ENVIRONMENTAL DATA LIST ***
LOCATION: 23.2N - 061.3E   DATA/TIME: 23rd day - 2300Z

	PRESS	TEMP	RH	DEW PT					
LEVEL	(MB)	(C)	(%)	DEP(C)	METERS	N UNITS	N/KM	M UNITS	CONDITION
1	1009.0	25.6	77.2	4.2	9.0	368.3	-187.1	369.7	TRAP
2	1000.0	25.2	44.3	13.0	88.0	319.8	-45.3	333.6	SUPER
3	986.0	26.4	32.0	18.1	212.0	301.4	-13.5	334.6	NORMAL
4	850.0	19.0	19.2	24.1	1502.2	244.2	-7.1	480.0	NORMAL
5	746.0	8.8	24.8	19.1	2601.4	218.5	-4.7	626.8	NORMAL
6	700.0	5.8	35.7	14.2	3125.0	210.5	-8.1	701.0	NORMAL
7	630.0	.4	28.8	16.2	3978.8	187.7	-2.3	812.2	NORMAL
8	564.0	-6.7	87.0	1.8	4855.4	181.1	-8.5	943.2	NORMAL
9	533.0	-9.3	74.9	3.6	5295.4	168.8	-5.4	1000.0	NORMAL
10	500.0	-13.3	89.1	1.4	5786.3	160.1	-4.8	1068.3	NORMAL
11	487.0	-15.5	100.0	.0	5986.3	156.9	-24.8	1096.5	SUPER
12	480.0	-15.1	34.9	12.2	6095.7	148.0	-2.5	1104.8	NORMAL
13	444.0	-18.1	95.8	.5	6682.1	143.1	-18.8	1192.0	NORMAL
14	437.0	-18.1	33.9	12.2	6800.9	135.8	-2.9	1203.3	NORMAL
15	409.0	-21.5	76.5	3.0	7292.6	131.0	-6.0	1275.7	NORMAL
16	400.0	-21.7	69.2	4.1	7456.7	127.8	----	1298.2	------

SURFACE REFRACTIVITY: 368.6 - - - SET SPS-48 TO   377.0

Figure 13. Environmental data list.

```
+------------------------------------------------------------------+
|             Radar Free Space Detection Range Calculations        |
+------------------------------------------------------------------+
|     Target size (0.001 to 1E7): [ 1 ] dBsm                       |
|     Probability of detection (0.1 to 0.9): .9                     |
|     Probability of false alarms (1E-4 to 1E-12): 1E-8            |
|     Type of target (Fluctuating,Steady): Fluctuating            |
+------------------------------------------------------------------+
```

Height finder radar: NO
Frequency: 220.0 MHz
Peak power: 750.0 kW
Pulse length: 10.0 usec
Receiver noise figure: 4.5 dB
Antenna gain: 18.5 dB
Assumed system loss: 12.0 dB
Pulse rate: 300.0 pps
Horizontal beam width: 20.0 deg
Horizontal scan rate: 15.0 rpm
Number of hits per scan: N/A
Classification:
Free-space range: 70.6 km   38.1 nm
Path loss at free space range: 116.3 dB

F1-Exit   F9-Toggle Units/Values

Figure 14. Radar free-space detection range input screen.

3.6.5 Utility Option 5—Free-Space Intercept Range

As with radar systems, the best method of determining a range for UHF communications or ESM intercept is by observation. While this method is easily employed for communication systems, an observed range for an ESM intercept is very rare.

For occasions where making an observation is impractical, the free-space intercept range may be calculated. Figure 15 illustrates the input screen for this calculation.

The free-space intercept range can be extremely large, on the order of many thousands of kilometers, which would be an ESM receiver's capability in free space. However, the influence of the earth and other factors, such as atmospheric absorption and scattering, limit the actual intercept range to a value much less than the free-space range. It may happen, however, that the calculated free-space intercept range in kilometers or nautical miles exceeds the limits of IREPS PC-2.0 inputs. In this case, the path-loss threshold in decibels may be substituted.

```
┌─────────────────────────────────────────────────────────┐
│           Free Space Intercept Range Calculations        │
├─────────────────────────────────────────────────────────┤
│   Transmitter power (.1 to 10000): ███ kW                │
│   Frequency (100 to 20000): 5000   MHz                   │
│   Gain of the transmitter antenna (0 to 100): 32    dB   │
│   Sensitivity of the receiver (-150 to 0): -85    dB     │
└─────────────────────────────────────────────────────────┘
```

ESM free-space intercept range: 57065.2 km
                                     30793.0 nm
Path loss threshold: 201.6 dB

F1-Exit   F9-Toggle Units/Values

Figure 15. Free-space intercept input screen.

3.6.6 Utility Option 6—Surface Refractive Conditions

The surface refractive conditions utility is used when surface meteorological measurements are available but a radiosonde sounding is not. The utility will calculate the evaporation duct height and the surface refractivity in N-units from inputs of surface air temperature, sea-surface temperature, surface relative humidity, surface atmospheric pressure, and surface wind velocity. In addition, this utility will determine the proper setting for the SPS-48 switch, which compensates for the surface refractivity variations. Figure 16 illustrates the menu for the type of calculation desired, and Fig. 17 and 18 illustrate the respective input screens for the evaporation duct height and surface refractivity calculations.

```
┌─────────────────────────────────────────────┐
│                                             │
│          SURFACE REFRACTIVE CONDITIONS      │
│                                             │
├─────────────────────────────────────────────┤
│   ███ Evaporation duct height               │
│   2   Refractivity (N-units)                │
│   Esc Main Menu                             │
└─────────────────────────────────────────────┘
```

Figure 16. Surface refractive conditions menu screen.

18

```
┌─────────────────────────────────────────────────────────────┐
│                   Evaporation Duct Height                     │
├─────────────────────────────────────────────────────────────┤
│                                                               │
│      True wind speed (0 to 100): ▓10▓▓▓ knots                 │
│      Sea temperature  (0 to 110): 59     deg F                │
│      Air temperature (-110 to 130): 59      deg F             │
│      Relative humidity (0 to 100): 80    %                    │
│                                                               │
└─────────────────────────────────────────────────────────────┘
```

EVAPORATION DUCT HEIGHT CALCULATION
True wind speed: 5.1 m/sec   10.0 knots
Sea temperature: 15.0 deg C   59.0 deg F
Air temperature: 15.0 deg C   59.0 deg F
Relative humidity: 80.0 %   80.0 %
Evaporation duct height: 9.3 meters   30.6 feet

F1-Exit   F9-Toggle Units/Values

Figure 17. Evaporation duct height input screen.

```
┌─────────────────────────────────────────────────────────────┐
│                   Refractivity (N-units)                      │
├─────────────────────────────────────────────────────────────┤
│                                                               │
│      Air temperature (-110 to 130): ▓59▓▓▓ deg F              │
│      Relative humidity (0 to 100): 80    %                    │
│      Pressure (26.58 to 33.86): 29.92   inches Hg             │
│                                                               │
└─────────────────────────────────────────────────────────────┘
```

REFRACTIVITY CALCULATION
Air temperature: 15.0 deg C   59.0 deg F
Relative humidity: 80.0 %   80.0 %
Pressure: 1013.2 mb   29.9 inches Hg
N-units: 334.2   334.2
Set SPS-48 switch to 344

F1-Exit   F9-Toggle Units/Values

Figure 18. Surface refractivity input screen.

3.6.7 Utility Option 7—Change User Data File Paths

As discussed in section 2.4, you may change the file search path for IREPS PC-2.0, which will enable you to access data from floppy diskettes or from multiple directories. By selecting this utility, you will be presented with the input screen illustrated in Fig. 19. Only valid DOS file and directory symbols are allowed.

```
+------------------------------------------------------------------+
|                         CURRENT PATHS                            |
+------------------------------------------------------------------+
|Environmental Data Files: C:\IREPS\ENV\                           |
|Cover System Files      : C:\IREPS\COV\                           |
|Loss System Files       : C:\IREPS\LOS\                           |
|Radar System Files      : C:\IREPS\RAD\                           |
|Automode Files          : C:\IREPS\AUT\                           |
+------------------------------------------------------------------+
```

F1-Save & Exit   F2-Exit W/O Save

Figure 19. Data file path input screen.

3.6.8 Utility Option 8—Change Default Units

Many input parameters have associated units. For example, an input of range may have units of kilometers, nautical miles, or statute miles; or an input of sea temperature may have units of Celsius or Fahrenheit. The system of units, i.e., English or metric, may be specified within this utility. To change the system of units, simply press the <space> bar until the desired system appears within the input field. This utility will only change the default system. You may still change individual units associated with particular input parameters while working with any input screen. The default is "English."

As discussed in section 2.3, commercial graphics screen dumping programs may or may not issue a form-feed command to the printer after a screen graphic has been printed. For this reason, IREPS PC-2.0 contains an option for issuing a form-feed command. If you use GrafPlus or Pizazz with their form-feed setting "Yes," press the <space> bar to toggle the IREPS form feed to "NO." If you use GrafPlus or Pizazz with their form-feed setting "NO" or another program without a form-feed option, press the <space> bar to toggle the IREPS form feed to "YES." Note! Using both the graphics dumper form feed and the IREPS form feed will cause a blank page to be printed between consecutive screen dumps. The default is "NO."

Figure 20 illustrates the input screen for establishing default units and a form feed.

```
┌─────────────────────────────────────────┐
│            CURRENT DEFAULT UNITS         │
├─────────────────────────────────────────┤
│         Default Units: ENGLISH           │
│         Auto form feed: NO               │
└─────────────────────────────────────────┘
```

F1-Save & Exit   F2-Exit W/O Save   F3-Toggle Units/Values

Figure 20. Default units input screen.

3.6.9 Utility Option 9—Change Classification Labels

IREPS PC-2.0 allows you to *label* your data with three different classification labels. For example, you may define classification label 0 as "UNCLASSIFIED," classification label 1 as "RESTRICTED," and classification label 2 as "MY EYES ONLY." **Note!** It is your sole responsibility to adhere to the data security requirements dictated by higher authorities. This utility is strictly a convenience *labeling* feature. NOSC assumes no responsibility for any unauthorized release of classified data by the misuse of this labeling utility. Figure 21 illustrates the input screen for this utility.

```
┌─────────────────────────────────────────┐
│        CURRENT SECURITY CLASSIFICATIONS  │
├─────────────────────────────────────────┤
│ Classification 1 Label: Classification   │
│ Classification 2 Label: Classification   │
│ Classification 3 Label: Classification   │
└─────────────────────────────────────────┘
```

F1-Save & Exit   F2-Exit W/O Save

Figure 21. Classification labels input screen.

4.0 INPUT PARAMETERS, DEFAULTS, AND LIMITS

Usually an input field will contain a default value and, if a numerical input field, a unit and limits. In some cases, the units are fixed. In other cases, the default units will depend on the global default setting of utility option 8. For example, if the global default is English, units of height will be feet, units of length will be nautical miles, and units of temperature will be Fahrenheit. If the global default is metric, units of height will be meters, units of length will be kilometers, and units of temperature will be Celsius.

4.1 ENVIRONMENTAL PARAMETERS

Pressing the <F5> NEW special function key from the file name screen of IREPS PC-2.0 option 1 (Select/Enter Environmental Data) will present the data type menu screen illustrated in Fig. 22. A selection from this menu screen will produce an input screen appropriate to the type selected. The default is data type <R>.

```
┌─────────────────────────────────────────────────────┐
│                                                      │
│            ENVIRONMENTAL DATA TYPE                   │
│                                                      │
├─────────────────────────────────────────────────────┤
│  R  RSONDE Pressure,Temperature,Relative Humidity    │
│  M  M-unit Height vs. M-units                        │
│  N  N-unit Height vs. N-units                        │
│  W  WMO    WMO Code Data                             │
│  Esc Main Menu                                       │
└─────────────────────────────────────────────────────┘
```

Figure 22. Environmental data type menu screen.

Environmental data may be obtained from your own local observations, from the Naval Oceanography Command Center responsible for your area of operation, from another ship with an oceanographic division or an embarked Naval Oceanography Command mobile environmental support team, from any organization having the capability of meteorological balloon launches, and from channels 8 and 16 of the Fleet multichannel broadcast. For additional information, U.S. Navy personnel may refer to NAVOCEANCOMINST 3140.1 series, "U.S. Navy Meteorological and Oceanographic Support Manual," and FLENUMOCEANCENINST 3140.3 series, "Automated Product Request User's Manual."

As an instructional aid, on the IREPS distribution computer disk we provide three sample environmental conditions files: one for a standard atmosphere called ENVIRO.STD; one for a 13-meter evaporation duct called ENVIRO.EVP; and one with a 300-meter surface-based duct called ENVIRO.SBD. *Do not use these sample files for the real-time assessment of your EM systems.*

For all new environments, a series of initial inputs are required, some of which are common to all environmental input types. These inputs appear on the top portion of the input screen.

Inputs appropriate to the environmental data type chosen from the menu screen (Fig. 22) appear on the bottom portion of the input screen. These inputs occur as couplets or triplets of data associated with a height level of the atmosphere. As the input fields are filled and closed, the highlight bar will automatically move to the next input field. You may use the arrow keys or a mouse to move the highlight bar back to a level that may require correction. The <Del> key will delete the line under the highlight bar. The <Ins> key will insert a blank line above the highlight bar.

4.1.1 Common Environmental Surface Parameters

a. *Location*. Any 20 characters you choose, generally the latitude and longitude of the radiosonde sounding. The default value is NOT SPECIFIED.

b. *Date/Time*. Any 20 characters you choose, generally the time of the radiosonde launch. The default value is NOT SPECIFIED.

c. *Type of Input*. Either RSONDE, M-unit, N-unit, or WMO. This field will contain the value specified from the environmental data type menu screen and may not be changed at this point.

d. *Units of Height in M (Meters) or F (Feet)*. The units to be used on the PROPAGATION CONDITIONS SUMMARY product. This is a toggle character field. The default is determined from the global default setting of utility option 8.

e. *Wind Speed*. True wind speed must be ≥ 0 and ≤ 100 kt (knots) or ≥ 0 and ≤ 50 m/s (meters/ second). The defaults are 10 kt and 5 m/s.

f. *Evaporation Duct Source*. This is a toggle field with three choices. If PARAMETERS is selected, the evaporation duct height will be calculated from your inputs of air temperature, sea-surface temperature, relative humidity, and wind speed. If SPECIFIED is selected, you may enter a value for the duct height. If WORLD AVG is selected, the evaporation duct height will be set to 13 meters. The default is PARAMETERS.

g. *Sea Temperature*. The temperature at the sea surface is best measured with an accurate thermometer and a small bucket that has been lowered into water undisturbed by the ship's wake. Satisfactory measurements are also obtainable by using the surface temperature from an expendable bathythermograph (XBT) if the XBT is not launched into the wake. Injection water temperature measurements are very inaccurate for the purpose required here and should be avoided if at all possible. Sea temperature must be ≥ 0° and ≤ 40°C or ≥ 0° and ≤ 110°F. The defaults are 15°C and 59°F. If the evaporation duct height source is SPECIFIED or WORLD AVG, sea temperature will not be requested.

h. *Air Temperature*. The temperature of the air is best measured with a hand-held psychrometer at any location above 6 meters (20 feet). Care should be taken to minimize any ship-induced effects such as heating from exhausts vents or radiating surfaces. Air temperatures must be ≥ -80° and ≤ 50°C or ≥ -110° and ≤ 130°F. The defaults are 15°C and 59°F.

i. *Relative Humidity*. Relative humidity is best measured along with the air temperature, as described above. Humidity must be ≥ 0 and ≤ 100%. The default is 80%.

j. *Radiosonde Launch Height Above Mean Sea Level (MSL)*. This is the height above mean sea level at which the radiosonde is released. Launch heights can be obtained from a WMO Station Index for land stations or, in the case of ships, estimated. The height must be ≥ 0 and ≤ 300 m or ≥ 0 and ≤ 1000 ft. The default is 0.

k. *Station Pressure at Launch Height*. This is the station pressure corrected to the radiosonde launch height. It is also the pressure of the surface level of the sounding. Station pressure must be ≥ 900 and ≤ 1100 mb (millibars) or ≥ 26.58 and ≤ 33.86 "Hg (inches of mercury). The defaults are 1013.2 mb and 29.92 "Hg.

l. *Height Offset From MSL*. Height offset from mean sea level is the initial height to which all subsequent heights are referenced. This height is normally zero. An example of a nonzero offset would be data from a refractometer-equipped aircraft in which the heights of the profile are computed as height above launch height. The height offset in this case would be the height of the refractometer above sea level at the time of aircraft launch. The height must be ≥ 0 and ≤ 300 m or ≥ 0 and ≤ 1000 ft. The default is 0.

4.1.2 Radiosonde Input

A response of <R> to the environmental data type menu will indicate that radiosonde data are to be entered. When selected, an input screen (Fig. 23) will be displayed. The radiosonde data are entered sequentially as pressure, temperature, and relative humidity at each significant level, beginning with the first level above the launch height. Pressures must be in decreasing order, with additional data restrictions for temperature and humidity as defined above. Normally, only data up to approximately 6300 meters (20,000 feet or 500 mb) are required, since almost all significant refractive effects occur below this altitude. There are no restrictions on the number of significant levels. There are no defaults.

```
┌─────────────────────────────────────────────────────────────────────────┐
│                              radiosonde                                   │
├─────────────────────────────────────────────────────────────────────────┤
│                                                                           │
│     Location: 23.2N - 061.3E                                              │
│     Date/Time: 23rd day - 2300Z                                           │
│     Type of input: RSONDE                                                 │
│     Units of height in M-Meters or F-Feet: METERS                         │
│     Wind speed  (0 to 50): 5.1  m/sec                                      │
│     Evaporation duct source (World Avg, Specified, or Parameters): SPEC    │
│     Evaporation duct height  (0 to 40): 13    meters                       │
│                                                                           │
│                                                                           │
│                                                                           │
│     Station pressure at launch height      (900 to 1100): 1009.0 mb       │
│     Radiosonde launch height above MSL  (0 to 300): 9      meters         │
├────────────────────────────────────────────────────────────┬──┬─────────┤
│ Level    Pressure    Temperature    Relative Humidity       │ ↑ │ Del     │
│   1       1009.0        25.6              77.2               │   │         │
│   2       1000.0        25.2              44.3               │   │         │
│   3        986.0        26.4              32.0               │   │         │
│   4        850.0        19.0              19.2               │   │         │
│   5        746.0         8.8             ▓▓24.0▓             │ ↓ │ Ins     │
└────────────────────────────────────────────────────────────┴──┴─────────┘
```

F1-Save & Exit   F2-Exit W/O Save   F3-Print   F9-Toggle Units/Values   F10-Copy

Figure 23. Radiosonde input screen.

4.1.3 Height Versus M- or N-Units

A response of <M> or <N> to the environmental data type menu will indicate that modified refractivity (M) or refractivity (N) data are to be entered. Figure 24 illustrates the M-unit input screen. The profile data are entered sequentially as height and M- or N-units. Heights must be increasing, M-units must be ≥ 50 and ≤ 1500 units, and N-units must be ≥ 50 and ≤ 450 units. There are no defaults.

```
┌─────────────────────────────────────────────────────────────────────┐
│                              M-units                                  │
├─────────────────────────────────────────────────────────────────────┤
│                                                                       │
│        Location: 23.2N - 061.3E                                       │
│        Date/Time: 23rd day - 2300Z                                    │
│        Type of input: M-unit                                          │
│        Units of height in M-Meters or F-Feet: METERS                  │
│        Wind speed  (0 to 50): 5.1  m/sec                          ·   │
│        Evaporation duct source (World Avg, Specified, or Parameters): SPEC │
│        Evaporation duct height  (0 to 40): 13    meters               │
│                                                                       │
│                                                                       │
│                                                                       │
│        Height offset from MSL              (0 to 300): 9     meters    │
├──────────────────────────────────────────────────────────┬──────────┤
│  Level        Height          M-units                     │ ↑  │ Del │
│    1            9.0            369.7                       │    │     │
│    2           88.0           333.6                       │    │     │
│    3          212.0           334.6                       │    │     │
│    4         1502.2           480.0                       │    │     │
│    5         2601.4          ▓▓626.8▓▓                     │ ↓  │ Ins │
└──────────────────────────────────────────────────────────┴──────────┘
```

F1-Save & Exit F2-Exit W/O Save F3-Print F9-Toggle Units/Values F10-Copy

Figure 24. M-unit input screen.

4.1.4 WMO Code Data

A response of <W> to the environmental data type menu will indicate that WMO-coded radiosonde data are to be entered, as illustrated in Fig. 25.

The WMO message is composed of two parts, labeled XXAA and XXBB. Section XXAA reports data for standard isobaric surfaces (mandatory levels) up to and including 100 mb. Section XXBB reports data for significant levels with respect to temperature and humidity up to and including 100 mb. The profile data necessary for IREPS PC-2.0 are the significant level code groups from section XXBB of the coded message; that is, the code groups which start with 00, 11, 22, etc. (Mandatory levels may also be significant but are, occasionally, left out of the significant level section. For this reason, it may be advantageous to merge sections XXAA and XXBB.)

```
┌─────────────────────────────────────────────────────────────────────────┐
│                                   WMO                                     │
├───────────────────────────────────────────────────────────────────────┬─┤
│    Location: 23.2N - 061.3E                                             │ │
│    Date/Time: 23rd day - 2300Z                                          │ │
│    Type of input: WMO                                                   │ │
│    Units of height in M-Meters or F-Feet: METERS                        │ │
│    Wind speed  (0 to 50): 5.1  m/sec                                    │ │
│    Evaporation duct source (World Avg, Specified, or Parameters): SPEC  │ │
│    Evaporation duct height  (0 to 40): 13    meters                     │ │
│                                                                         │ │
│                                                                         │ │
│                                                                         │ │
│    Radiosonde launch height above MSL  (0 to 300): 9     meters         │ │
├──────────────────────────────────────────────────────────────┬─────────┴─┤
```

Level	PPP - Pressure	TTTDD - Temp. Dew Point Depr.		
00	009	25643	↑	Del
11	000	25263		
22	986	26468		
33	850	19074		
44	746	**08869**	↓	Ins

F1-Save & Exit   F2-Exit W/O Save   F3-Print   F9-Toggle Units/Values   F10-Copy

Figure 25. WMO input screen.

To illustrate an actual WMO message and to aid you in the interpretation of the message, the following message and an explanation of each code group is provided. This example message is used to produce Fig. 13 and 25.

UUAA 7323/ 99232 10613 10231 99009 25643 26010 00090 25263
85504 19074 70127 05864 50579 13314 40746 21741 88999 77999

UUBB 7323/ 99232 10613 10231 00009 25643 11000 25263 22986
26468 33850 19074 44746 08869 55700 05864 66630 00466 77564
06718 88533 09336 99500 13314 11487 15500 22480 15162 33444
18105 44437 18162 55409 21530 66400 21741

4.1.4.1   WMO Code Mandatory Level Section XXAA

XXAA YYGGI$_d$ IIIiii (for land stations)

XXAA 99L$_a$L$_a$L$_a$Q$_c$L$_o$L$_o$L$_o$L$_o$ (for ship stations)

99P$_o$P$_o$P$_o$T$_o$T$_o$T$_{ao}$ D$_o$ D$_o$ d$_o$ d$_o$ f$_o$ f$_o$ f$_o$

00hhh TTT$_a$DD ddfff

85hhh TTT$_a$DD ddfff

70hhh TTT_aDD ddfff

$\vdots$

10hhh TTT_aDD ddfff

4.1.4.2 WMO Code Significant Level Section XXBB

$XXBB_d$ YYGGI IIiii (for land stations)

XXBB $99L_aL_aL_aQ_c$ $L_oL_oL_oL_o$ $MMMU_{La}U_{Lo}$ (for ship stations)

$00P_oP_oP_o$ $T_oT_oT_{ao}$ D_oD_o

11PPP TTT_aDD

22PPP TTT_aDD

$\vdots$

4.1.4.3 Definition of WMO Code Groups

a. XXAA or XXBB group

XX – identifier letters for the code form. TT if land station and UU if ship station.
AA (or BB) – identifier for the section of the code form

b. $YYGGI_d$ group
YY – day of month (50 is added to the day if the wind is reported in knots, otherwise the wind reported is meters per second).
GG – nearest whole hour (GMT) of balloon launch
I_d – 100's of millibars relative to the last surface for which wind is reported.

c. station identification groups
for land station
II – block number assigned to individual countries by WMO
iii – station number assigned by individual country

for ship station
99 – indicator for a sea station
$L_aL_aL_a$ – latitude (degrees and tenths)
Q_c - quadrant of globe (1=NE, 3=SE, 5=SW, 7=NW)
$L_oL_oL_oL_o$ – longitude (degrees and tenths)
MMM – Marsden square number for ship location
U_{La} – units digit of latitude
U_{Lo} – units digit of longitude

d. surface observational groups
$99P_oP_oP_o$ group
99 (00 for ships) – indicator for surface data
$P_oP_oP_o$ – extrapolated surface pressure in whole millibars (hundreds, tens, and units)

28

$T_oT_oT_{ao}\,D_oD_o$ group

    T_oT_o – air temperature in whole degrees Celsius

    T_{ao} – approximate tenths value and plus or minus sign. Even for plus temperature, odd for negative temperatures.

    D_oD_o – depression of dew point temperature

e.   standard isobaric surface data groups

xxhhh group

    xx – hundreds and tens of pressure surface (i.e., 00 = 1000 mb, 85 = 850 mb, etc.)

    hhh – geopotential height (in meters or tens of meters) of the isobaric surface specified

$TTT_a\,DD$ group

    TT – air temperature in whole degrees Celsius

    T_a – approximate tenths value and plus or minus sign indicator

    DD – dew point depression temperature

ddfff group

    dd – true direction in tens of degrees from which the wind is blowing

    fff – wind speed in knots or meters per second

f.   significant isobaric data groups

xxPPP group

    xx – number of level above the earth's surface (i.e., 11, 22, 23, etc.)

    PPP – pressure in tens or whole millibars

$TTT_a\,DD$ group

    same as described for standard isobaric data.

4.2 ELECTROMAGNETIC SYSTEM PARAMETERS

In order to generate an IREPS PC-2.0 product, you must provide the program with various parameters for the EM system. You are solely responsible for the determination of these parameters. For this reason, you are reminded that IREPS PC-2.0 is designed to give relative performance assessments for various systems rather than an absolute performance value for a particular system. To assist in a standardization effort, NOSC has published a Technical Document.[*]

These input parameters may be grouped into several categories, depending upon the system in question. As a training aid, several electromagnetic system files have been provided on the IREPS PC-2.0 distribution diskette. These system files are positioned within the IREPS PC-2.0 default directory structure as defined in section 2.4. The following is a brief description of each system parameter required.

4.2.1 Platform or System Location

There are two options for platform type, namely a SURFACE or an AIRBORNE platform. Surface platforms are primarily those associated with shipboard systems. However, a surface platform could be specified for any system with a transmitter between 3 and 300 feet (1 to 100 meters) above sea level. The primary difference between platforms is that calculations for the interference region are included for surface systems but not for airborne systems. The default is SURFACE.

4.2.2 Transmitters

Over the years, many different types of transmitters have been developed to perform special demands of the radar such as moving target indication (MTI), pulse doppler, continuous waveforms (CW),

---

[*] Patterson, W.L., "Selected Electromagnetic System Parameters for Use in the Tactical Environmental Support System (TESS) (U)," NOSC TD 1195. Rev. 1, September 1990. (SECRET).

phased-array radar, EM compatibility (EMC), and electronic counter-countermeasures (ECCM). The basic demand of the transmitter, however, is to generate power in the form of shaped waves. A number of terms associated with the transmitter are of concern to you:

a. *Frequency*. The frequency must be ≥ 100 MHz (megahertz) and ≤ 20,000 MHz, or ≥ 0.1 GHz (gigahertz) and ≤ 20.0 GHz. The default is 5000 MHz.

b. *Peak power*. Also referred to as pulse power, peak power is the instantaneous maximum power transmitted during a pulse. The peak power must be ≥ 0.1 and ≤ 10,000 kW (kilowatts). The default is 285 kW. **Note:** Peak power should not be confused with average power, which is averaged over the inter-pulse time period during pulse transmission and nontransmission; or with effective radiated power, which is adjusted for antenna gain and transmission line losses.

c. *Pulse length*. Pulse length is the length of time between the start and end of the pulse. Long pulse lengths have the advantage that large amounts of energy can be applied to a target in order to enhance its detectability. Long pulse lengths will lead to the longest range of detection and are therefore used in long-range search radars. Long pulse lengths have the disadvantage that fine details within the return echo will be lost, thereby reducing target resolution. For example, a long pulse length may be used to detect the presence of a harbor within a coast line but cannot be used to detect a pier within the harbor. The pulse length must be ≥ 0.1 and ≤ 9,999 μs (microseconds). The default is 1.3 μs.

d. *Pulse repetition frequency (pulse rate)*. Pulse rate is the number of pulses the transmitter generates each second. The prf must be ≥ 1 and ≤ 9,999 pps (pulses-per-second). The default is 650 pps.

e. *Unambiguous range (maximum instrumented range)*. After the transmitter sends out a pulse, it turns off and allows the receiver to "listen" for an echo. It may happen that a pulse will travel to a target and back, only to arrive while the transmitter is in the process of sending out another pulse. In such an event, the pulse is not received and the target is not detected. It may also happen that the pulse will return at some time after the transmitter has sent out a second pulse. In that circumstance, the target will appear closer to the transmitter than it really is. Echo signals received after an interval exceeding the pulse repetition period are call "multiple-time-around" echoes. Multiple-time-around echoes are often referred to as "radar ghosts." The range that a pulse can travel to and back in the time interval between pulses is known as the "maximum unambiguous range" or the "maximum instrumented range." The pulse rate is commonly "jittered" or constantly varied so that multiple-time-around echoes will bounce around in range on the display. This variation in range alerts the operator to the true nature of the target.

Often, the maximum unambiguous range will not be available in publications. It may be estimated with the following equation:

$$R_u = \frac{150,000}{prf} \text{ km} = \frac{81081}{prf} \text{nmi} \tag{1}$$

where *prf* = pulse repetition frequency (pulses per second).

The unambiguous range must be ≥ 0 and ≤ 500 nmi/sm (nautical/statute miles) or ≥ 0 and ≤ 1000 km (kilometers). A value of 0 represents a "not applicable" response. The default is 0.

f. *Assumed system losses*. As energy flows throughout the transmitter, receiver, and antenna system, some of it may be converted to heat, dissipated in the beamshape, or lost in system irregularities, and the system is therefore degraded from the ideal. A single number to account for this degradation is the assumed system loss. It is assumed because there is no practical way to accurately determine total losses. The assumed system loss must be ≥ 0 dB and ≤ 100 dB. The default is 8.4 dB.

4.2.3 Receivers

a. *Receiver sensitivity.* The function of the receiver is to detect EM radiation within a certain frequency band. The receiver is designed to detect a signal which exceeds a certain minimum power level. This minimum power level is the receiver's sensitivity. Any signal which exceeds the sensitivity will be detected. The receiver sensitivity must be ≥ -150 dBm (decibel relative to a milliwatt) and ≤ 0 dBm. The default is -85 dBm.

b. *Receiver noise.* Not all signals with power exceeding the sensitivity are desirable. Nondesirable signals are referred to as noise. Receiver noise is generated from thermal radiation and mechanical motions within the receiver. A quantitative measure of the noise is the "receiver noise figure." The receiver noise figure must be ≥ 0 dB and ≤ 100 dB. The default is 14 dB.

c. *Probability of detection.* In order to detect a signal, the receiver noise power must be less than the power of the desired signal, or in other words, the signal-to-noise ratio must exceed a certain value, commonly called a detection threshold. Since noise is a random process, the signal-to-noise ratio must be described in statistical terms, i.e., in probabilities. The probability of detection, therefore, depends upon the probability of the desired signal power exceeding the detection threshold. The probability of detection does not account for CRT display factors such as CRT brightness, blip size, and viewing distance; nor for operator factors such as fatigue or training. The probability of detection must be $\geq 10\%$ and $\leq 90\%$. The default is 90%.

d. *False-alarm rate.* Receivers are designed with a high enough detection threshold that most receiver noise will not exceed it. On occasion, however, noise will have sufficient power to exceed the threshold, resulting in a "false-alarm." A tolerable rate at which false alarms occur depends upon the nature of the radar application. False-alarm probabilities for most practical radars are quite small, on the order of 10^{-6} or smaller. The false-alarm rate must be $\geq 10^{-12}$ and $\leq 10^{-4}$. The default is 10^{-8}.

4.2.4 Antennas

The purpose of the radar antenna is to transfer power from the transmitter to the environment and from the environment to the receiver. The antenna shapes the energy into beams and directs it toward a desired direction in space. When the transmitter turns off, the antenna collects returning energy and directs it to the receiver.

a. *Horizontal scan rate.* The most commonly used antenna type employs some sort of reflective surface which rotates horizontally or nods up and down. These antennas are referred to as parabolic-reflector antennas. A beam is formed by directing the energy from a "horn" or "feed" against a parabolic-shaped reflecting surface, much like that of an automobile headlight. Newer antenna designs employ a series of fixed radiating surfaces. These surfaces are radiated electronically at different times, thereby forming the beam and changing its direction. This type of antenna is called a "phased-array" antenna. For non-height-finder radars, IREPS PC-2.0 assumes a horizontally rotating antenna. The horizontal scan rate must be ≥ 1 rpm (revolution-per-minute) and ≤ 100 rpm. The default is 15 rpm.

b. *Antenna type.* The distribution of energy into space relative to the antenna's axis of symmetry is called the "antenna pattern," its "power pattern," or its "radiation intensity pattern." The IREPS PC-2.0 antenna types or, more correctly, antenna patterns are—

OMNI—an antenna uniformly radiating in all directions. This type of antenna is normally employed with UHF communication systems where a whip antenna or a small aircraft-mounted antenna is used. It may be used for any system known to radiate nearly uniformly in all directions.

SIN(X)/X—the most common type of directional antenna used by most surface and air-search radars and by directional communication systems.

CSC² (cosecant-squared)—a special antenna used in some air-search and airborne radars. This type of antenna should only be selected if it is known to a certainty to be appropriate.

HT-FINDER (GENERIC)—A SIN(X)/X pattern that is automatically raised in elevation angle to look in the desired direction, thus constructing an antenna pattern appropriate for a height-finding radar.

The default is OMNI.

c. *Antenna beamwidths (horizontal and vertical).* The major concentration of energy from an antenna is along its axis of symmetry. This is known as the main beam or "lobe." The additional lobe structure of the antenna pattern outside the region of the main beam is called "sidelobes." Sidelobes cause problems in target detection because they allow energy from outside the desired direction to enter the system. This leads to false targets or increased susceptibility to radar jamming.

Normally the beamwidth is the width between half-power points; that is, an antenna with a 4-degree vertical beamwidth will radiate only half as much power 2 degrees above and below its axis of symmetry. The beamwidth, both horizontally and vertically, is most commonly expressed in degrees. The horizontal beamwidth must be > 0.5 degree and ≤ 90 degrees. The default is 10 degrees. The vertical beamwidth must be ≥ 0.5 degree and ≤ 45 degrees. The default is 10 degrees. In some cases, an antenna will have a vertical beamwidth greater than 45 degrees. Since refraction plays little to no role at steep angles, the use of 45 degrees for these systems will provide an acceptable answer.

d. *Elevation angle.* The axis of symmetry of the antenna is measured from the local horizontal (zero degrees) and increases in an upward direction to form the elevation angle. For most surface-based systems, this angle will be zero. For many airborne radars, this angle will be slightly downward (negative elevation angle). Except in special circumstances, the height-finder elevation angle will be zero. The elevation angle must be ≥ -10 degrees and ≤ 10 degrees. The default is 0 degrees.

e. *Antenna gain.* The ability of an antenna to concentrate energy into a particular pattern or be more sensitive to energy arriving from ~ specific direction is called antenna "gain." The gain of the antenna is a function of the antenna's aper re (the physical area of the antenna face), shape, and construction details. Greater antenna p r mean better target detection. The antenna gain must be ≥ 0 dB and ≤ 100 dB. The default is 32 dB.

f. *Hits-per-sc n.* As discussed above, in order to detect a target, an acceptable signal-to-noise ratio must be obtained. One way to accomplish this is by applying more energy on the target. Applying more energy on the target may be accomplished by increasing the number of pulses striking the target as the radar beam scans over the target. For simple radars, the number of hits-per-scan is calculated from the antenna's horizontal beamwidth, the pulse repetition frequency, and the horizontal scan rate of the antenna. For other types of radars, the number of hits-per-scan must be specified explicitly. The number of hits-per-scan must be ≥ 1 and ≤ 99,999. The default is 10.

g. *Polarization.* In order to take advantage of surface reflections or to help the radar "see" through weather disturbances, the direction of the electric field of the antenna may be oriented one of several ways. The electric field orientation is called antenna "polarization." Most radar antennas are linearly polarized. In other words, the direction of the electric field is either horizontal or vertical with respect to the earth's surface. Polarization may also be elliptical or circular. Elliptical polarization is the combination of two linearly polarized waves of the same frequency, traveling in the same direction, which are perpendicular to each other. The relative amplitude and phase relationships between the two may be of any value. If the two wave amplitudes are equal and they are 90 degrees out of phase, the polarization is circular. You must specify the polarization of the antenna, either HORIZONTAL, VERTICAL, or CIRCULAR. The default is HORIZONTAL.

h. *Antenna height.* The model which calculates the coverage display for surface-based systems is valid only for antenna heights ≥ 1 meter and ≤ 100 meters or ≥ 3 feet and ≤ 300 feet. The defaults are

30 meters and 100 feet. This should not be a restriction on any normal application of ship-based systems, including submarines operating at periscope depth. The antenna height for an airborne system is limited to the maximum height of the coverage display that has been requested or ≤ 100,000 feet (≤ 30,000 meters) for the loss display.

4.3 NONRADAR ELECTROMAGNETIC SYSTEMS

A large array of EM systems with varied uses may be grouped together for the purposes of performance assessment. These "communication" systems range from simple radiosonde transmitters to systems such as identification-friend-or-foe (IFF) or radio communications or ESM receivers, to extremely sophisticated systems such as ECM jammers.

No matter the design of the system, the basic concepts of transmitters, receivers, and antennas, such as transmitter power and frequency, receiver sensitivity, and antenna polarization (as described above), also apply to these systems. However, any two-way transmission-path consideration, such as an unambiguous range, does not apply.

4.4 TARGET PARAMETERS

In addition to the electronic characteristics of the radar system and the refractive effects of the troposphere upon the propagating EM wave, the detectability of an object depends upon the nature of the object itself. While there are hundreds of ways to classify a target, you are required to describe the radar target by its size (radar cross-section) and its type (Swerling case).

4.4.1 Target Size

A target's radar cross-section is a term used to describe the signal scattering efficiency of the target. It is a function of the target's shape, the materials it is made of, the angle at which it is viewed (which implies a range dependency), the radar frequency, and the polarization of the transmitting and receiving antennas.

While it is commonly held that the radar cross-section is independent of range, this is only true when the range is sufficiently great or the target is sufficiently small (such as a missile nose cone), so as to cause the incident wave to be in the same plane as the receiver. This is often referred to as the "far-field" assumption, or the target is considered to be a "point-source" target. For short ranges, or for a very large target (such as a ship), the viewing angle becomes important. The target in this case is known as a "distributed target."

The units of radar cross-section are units of area. In early work, the common unit was the square foot, but currently the accepted unit is square meter. The radar cross-section may be referenced to a selected "standard" cross-section; it also may be expressed in decibels relative to this standard. Most commonly, the standard is a radar cross-section of 1 square meter. Thus, a target's radar cross-section may be expressed in decibels relative to 1 square meter (dBsm).

The most direct way to determine the radar cross-section is to illuminate the target, or a scale model of it, with a well-calibrated radar and measure the return signal. Other ways are by direct solution of Maxwell's equations for the boundary conditions appropriate to the object (usually impossible for all but the simplest shapes) or by some approximation technique based upon EM theory.

For the purposes of IREPS PC-2.0, an air target is considered a "point-source" target and you must specify the radar cross-section directly. The radar cross-section must be > 0 and ≤ 10,000,000 sqm or

33

dBms. The default is 0.1. NOSC Technical Document 1195[*] contains a listing of measured radar cross-sections for various aircraft targets. A ship target is considered a "distributed target" and the radar cross-section (σ) is approximated by

$$\sigma = 52 \, f^{0.5} \, D^{1.5} \tag{2}$$

where f is the frequency in megahertz and D is the ship's full load displacement in kilotons. Because the target's radar cross-section is a function of so many variables, a target's radar cross-section should never be extrapolated, inferred, or "guessed" from the cross-section of another target.

A typical example of radar cross-section in relation to target aspect is illustrated in Fig. 26. The three lines plotted on the polar diagram are the 20-, 50-, and 80-percentile values of the cross-section distribution function, inner to outermost curves, respectively. The cross-section values are plotted in decibels above 1 m², or in other words, the number of decibels above that corresponding to a 1 m² target. The fluctuations with aspect of 10 dB or greater can cause the detection range to vary an order of magnitude between the minimum and maximum values under the appropriate ducting conditions.
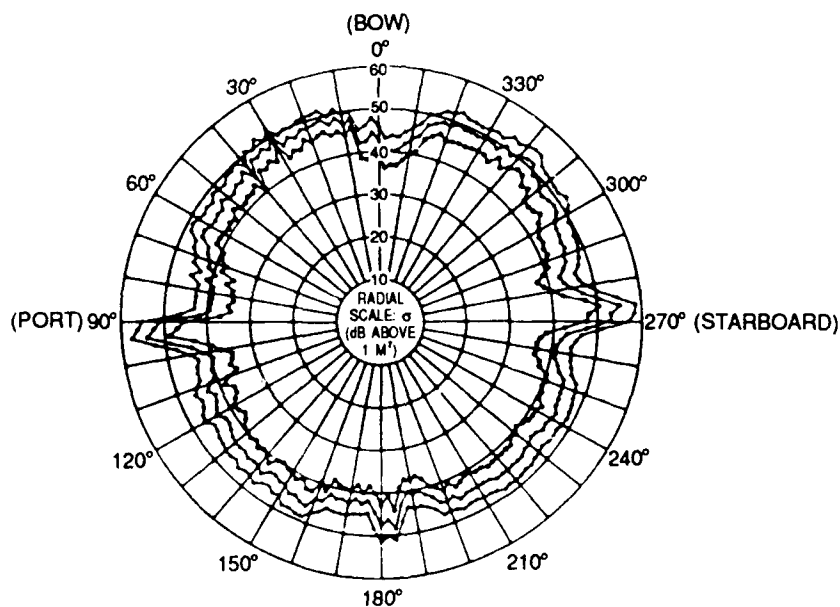
Figure 26. Variations of radar cross-section
with aspect for grazing-angle incidence.

4.4.2 Target type

Since the instantaneous radar cross-section of the target is a function of aspect angle, any target that is in relative motion with the transmitter will have a fluctuating radar cross-section. This fluctuation must be considered when computing the signal-to-noise ratio (and ultimately the probability of detection).

---

[*]Op. Cit.

In 1960, Swerling proposed four models for these fluctuations in radar cross-section. These models assume a time dependency or differing rates of fluctuation: a slow rate in which the fluctuation will be independent of the scan rate of the antenna but will be the same between pulses within one beamwidth; and a fast rate in which the fluctuations will be independent from pulse to pulse. A second dependency of the model is the probability of finding any particular value of target radar cross-section between two specified values. This probability is also referred to as the "probability-density" function.

These models are referred to as cases 1 through 4. Cases 1 and 2 employ one method of determining the probability-density function for a slow and fast fluctuating target, respectively. Cases 1 and 2 may be applied to a complex target consisting of many independent scattering surfaces, all of which are approximately the same size. Cases 3 and 4 employ an alternative method of determining the probability-density function for a slow and fast fluctuating target, respectively. Cases 3 and 4 may be applied to targets which consist of one large reflecting surface together with other small reflectors.

It is extremely difficult to determine which case to apply for any particular target. Within IREPS PC-2.0, the four target cases are combined into two, either a FLUCTUATING target or a nonfluctuating, STEADY target. Unless the target characteristics are known exactly, it is recommended that the fluctuating target case be used. For example, an aircraft target would normally be a fluctuating target. This selection will provide the most conservative value and will not produce an unreasonably high signal-to-noise ratio. The default is FLUCTUATING.

4.5 THRESHOLD PARAMETERS

Thresholds for radar detection, communication, or ESM intercept must be specified, either directly or from calculations performed in utility options 4 (section 3.6.4) or 5 (section 4.4). For surface-based systems, up to four thresholds may be entered. These thresholds must be entered in ascending order. For airborne systems, only one threshold may be entered. The thresholds may be entered as a free-space range in nautical miles or kilometers, or as available path-loss in decibels. The free-space range or available path-loss must be > 0 and ≤ 999,999. There are no defaults other than units of nautical miles or kilometers for free-space range as determined by the global unit setting.

4.6 DISPLAY PARAMETERS

The display parameters are for your convenience and have no influence upon the validity of the IREPS PC-2.0 models used to make a performance assessment. These parameters are as follows:

4.6.1 Display Scaling

The display defines the maximum altitude and range for the coverage display, or the maximum range for the loss display when these products are requested. The display scaling menu screen is illustrated in Fig. 27. (Note: Selecting a display will default the range/height units for the display only. Other range/height units will remained as specified by the global units setting.)

```
                    DISPLAY SCALING
          MAX ALTITUDE              MAX RANGE

      1   50000 FT                  200 NM
      2   25000 FT                  100 NM
      3   10000 FT                   50 NM
      4   20000 M                   400 KM
      5   10000 M                   200 KM
      6    5000 M                   100 KM
      7   User Defined Scales
      0   Used Defined Scales At Run Time
```

Figure 27. Display scaling menu screen.

Selecting display 7 allows you to specify the maximum range (up to 500 nmi/sm or 1,000 km) and height (up to 30,000 meters or 100,000 feet) for the coverage display and maximum range (up to 500 nmi/sm or 1000 km) for the loss display. In addition, metric and English units of measurement may be mixed or matched. Display 8 performs the same function as display 7 except that the numerical values may be specified at the time of actual product generation. You should be cautioned about selecting displays 7 and 8. Scale distortion may result for improperly selected values, thus making the coverage display hard to interpret or misleading upon casual inspection. The default is 1.

4.6.2   Classification Label

The IREPS PC-2.0 program will accept parameters from many different systems, some of which may be classified at differing security levels. As a convenience in labeling IREPS PC-2.0 products, a security classification appropriate to the system parameters may be entered. Note! This labeling convenience does not relieve you from the burden of security. It is your sole responsibility to handle any classified material in accordance with directives of higher authorities. There are no defaults.

4.6.3   User Labels

Two lines of labels, of up to 60 characters each, are provided for you to use in any manner you choose. It is a good idea to at least describe the system and to define what the free-space range value was based upon. There is no default.

4.7   AUTOMODE PARAMETERS

IREPS PC-2.0 option 5, AUTOMODE, is an automatic product generator designed for your convenience in providing IREPS support to other people, or for you in producing the same series of products on a routine basis. For example, you may be providing a daily IREPS briefing to several aircraft squadrons embarked aboard your aircraft carrier, or you may be the lone user on your frigate with a fixed electronic suite. In order to automatically produce IREPS PC-2.0 products, an automode recipe must be created. This recipe will be based upon the product user's desires.

Pressing the <F5> NEW special function key from the file name screen of IREPS PC-2.0 Edit
Automode System Files utility will present an input screen like that illustrated in Fig. 28. To the right of
the screen is a list of special function keys, one for each IREPS PC-2.0 product and one for a free format
remark. Pressing one of the special function keys will add that particular IREPS PC-2.0 product to the
automode recipe.

```
┌─────────────────────────────────────────────────────────────┐
│                         CUSTOMER.1                           │
├─────────────────────────────────────────────────────────┬───┤  Del
│████████████████████████████████████████████████████████│ ↑ │
│                                                         │   │
│                                                         │   │  Ins:
│                                                         │   │  F4-Rem
│                                                         │   │  F5-Env
│                                                         │   │  F6-Sumry
│                                                         │   │  F7-Cover
│                                                         │   │  F8-Loss
│                                                         │   │
│                                                         │   │
│                                                         │   │
│                                                         │   │
│                                                         │   │
│                                                         │ ↓ │
└─────────────────────────────────────────────────────────┴───┘
```
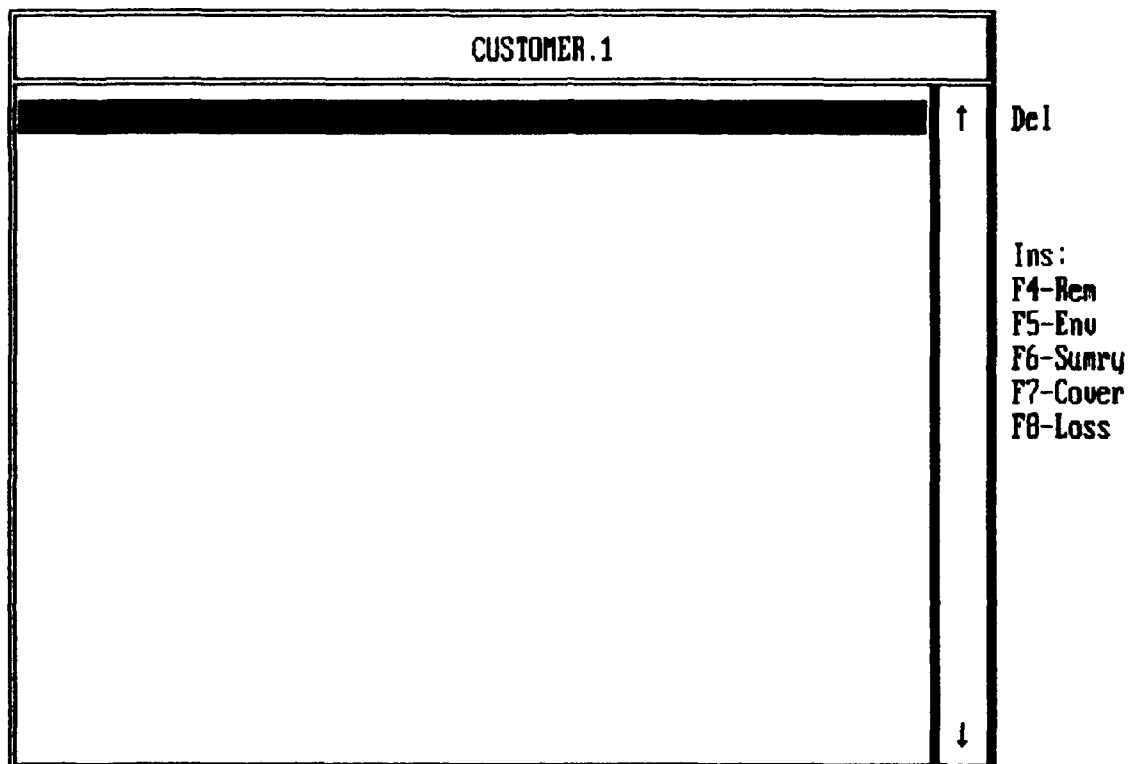
F1-Save & Exit   F2-Exit W/O Save   F3-Print   F9-Toggle Units/Values   F10-Copy

Figure 28. Automode recipe input screen.

As each product is requested, any additional information needed by the automode utility will be
prompted. For example, by pressing the <F7>-Cover key, you must provide a cover system file name; and
if the cover system is an airborne system, you must also provide a transmitter height. Because each system
is stored in its own file and you may have hundreds of files in your library, you may not remember a
particular file's name. In that case, entering a question mark, "?," in the file name field will produce the
appropriate file name screen. The file may then be selected by using the arrow keys or a mouse to
highlight the desired file and then pressing the <Enter> key or clicking the left mouse button.

Figure 29 illustrates an automode recipe created for a hypothetical customer. This customer requires a
PROPAGATION CONDITION SUMMARY, a current ENVIRONMENATAL DATA LIST, COVER-
AGE diagrams for his surface and air search radars, LOSS diagrams for two surface and one air search
radars, and three LOSS diagrams for use in the ESM intercept of some particular threat emitter. There is
no limit to the number of products which may be placed in a recipe. If you desire multiple copies of the
same product, just make a separate entry for each copy desired.

```
┌─────────────────────────────────────────────────────┐
│                     CUSTOMER.2                       │
╞═════════════════════════════════════════════════════╡
│REMARK ▓products routinely requested by customer 2▓ │↑│ Del
│REMARK                                              │ │
│REMARK         *** environmental summary and list of data ***  │
│SUMMARY                                             │ │
│CURRENT ENVIRONMENTAL DATA LIST                     │ │ Ins:
│REMARK                                              │ │ F4-Rem
│REMARK         *** Cover Diagrams ***               │ │ F5-Env
│COVER FOR SPS-AA                                    │ │ F6-Sumry
│COVER FOR APS-XX        TR/RA ALT 10000  FT         │ │ F7-Cover
│REMARK                                              │ │ F8-Loss
│REMARK         *** Loss Diagrams ***                │ │
│LOSS FOR SPS-AA         RE/TA ALT 10000  FT         │ │
│LOSS FOR SPS-BB         RE/TA ALT 5000   FT         │ │
│LOSS FOR APS-XX         TR/RA ALT 100    FT RE/TA ALT 15000  FT │
│REMARK                                              │ │
│REMARK         *** Loss Diagrams for ESM intercept ranges *** │
│LOSS FOR THREAT.1       RE/TA ALT 125    FT         │ │
│LOSS FOR THREAT.2       RE/TA ALT 500    FT         │ │
│LOSS FOR THREAT.3       RE/TA ALT 85     FT         │↓│
└─────────────────────────────────────────────────────┘
```

F1-Save & Exit   F2-Exit W/O Save   F3-Print   F9-Toggle Units/Values   F10-Copy

Figure 29. Sample automode recipe.

You may use the arrow keys or a mouse to move the highlight bar around the automode screen. Pressing the <Delete> key will delete the entry under the bar. Pressing one of the product keys will open a new line above the bar. A previously entered value may be changed just by highlighting the old value and overtyping with the new value.

Note! Because of the IREPS PC-2.0 file structure, over time you may delete or change the name of some particular system file. This change will *not* automatically be reflected in a previously constructed automode recipe. If the automode routine encounters a file name that no longer exits, a notice message will be printed on the paper in place of the product, and the automode routine will continue with the next product in the recipe.

38

5.0 LIMITATIONS OF THE IREPS PC-2.0 MODELS

You must be aware of a number of limitations in the IREPS PC-2.0 models and resulting products. The IREPS PC-2.0 models and software are constantly undergoing revisions and many of the following limitations will be overcome in the future.

a. *Frequency*. The frequency range for which the models have been developed is from 100 MHz to 20,000 MHz. The models specifically do not apply to any HF system.

b. *Clutter*. The models do not include any effects produced by sea or land clutter. This shortcoming may be of importance for air-search radars in the detection of targets flying above surface-based or strong evaporation ducts, but is not expected to significantly affect the predicted enhanced detection ranges within a duct.

c. *Horizontal homogeneity*. The IREPS PC-2.0 program does not account for horizontal changes in the refractivity structure. This restriction is not believed to be a serious one within open-ocean areas, since there exists scientific evidence that the atmosphere is horizontally homogeneous about 85 percent of the time for the purpose of making refractive effects assessments. You should be aware, however, of the changing state of the atmosphere and try to acquire and use refractivity measurements that are appropriate to the planned time and place of pertinent operations.

d. *Interference effects*. The models used within the coverage and loss products for an airborne system do not include interference effects. For airborne systems, the sea-reflected ray is ignored; surface systems are the only systems in which the coverage and loss products include the effects from a sea-reflected ray.

e. *Absorption*. There is no account made of absorption from oxygen, water vapor, fog, rain, snow, or other particulate matter in the atmosphere. Most of these absorption effects are minor over the valid frequency range of the models.

f. *Low elevated ducts*. The IREPS PC-2.0 models account for ducting in evaporation ducts. The models also account for ducting in surface-based and low elevated ducts, provided the transmitting antenna is within the duct. The models do not properly account for the over-the-horizon regions for low elevated ducts when the bottom of the duct is just above the antenna height. The calculated ranges for the coverage display will generally be less, and the path loss values for the loss display will be greater than the corresponding actual ranges. The error becomes less the higher the elevated duct is above the antenna height and should be insignificant when the separation exceeds a few thousand feet.

g. *Clutter/ECM*. The calculation of the free-space range does not consider any clutter-reduction features, such as sensitivity-time-constant (STC) and moving target indicator (MTI), active electronic countermeasures, or environmental noise. Overestimates of detection ranges may result when clutter-reduction features are used. These overestimates could be quite severe, even to the point of predicting a detection when one is not possible.

h. Product uses. The coverage display can be used for the following applications:

(1) Long-range air-search radars, surface-based or airborne

(2) Surface-search radars when employed against low-flying air targets

(3) Surface-to-air or air-to-air communications

The coverage display specifically should *not* be used for the following applications:

(1)   Airborne surface-search radars

For airborne (and surface-based) surface-search radars, the transmitted energy is reflected from the earth's surface. While most of this reflected energy will be directed away from the receiver, a portion will be directed back toward the receiver. "Radar clutter" or "backscatter" is the term used to describe this undesirable energy. The clutter level may be sufficient to lead to false targets or overpower the return from the desired target, thereby leading to undetected actual targets. Due to the complex nature of the reflecting surface, the IREPS PC-2.0 model does not consider the effect of sea-surface (or land) clutter. Therefore, the assessment provided by the coverage display is designed for use with targets which do not have a reflecting background, or in other words, no radar return from a surface other than the target. For this reason, the coverage display is inappropriate for an airborne surface-search radar.

A second consideration which makes the display inappropriate for an airborne surface-search radar is the very nature of the display design. Recall that the display is designed as a *height* versus range depiction of *airborne* targets by a radar. Since surface targets are not expected to occur at a height above the surface, a *height* display does not make sense.

(2) Surface-based surface-search radars.

For a surface-based surface-search radar, a major consideration in performance assessment is the target's radar cross-section. As explained in section 4.4, the target's radar cross-section is a function of the target's shape. Large, flat, smooth surfaces may reflect a large amount of energy, but the scattering will primarily be in one direction. Smaller, more angular surfaces may not reflect as much energy, but the area over which the energy is scattered may be very large indeed. It has been shown that the major energy return from a ship target is not from its smooth, large hull but from its superstructure with its highly angled and complicated structure.

In addition, for a very large target, the radar cross-section also becomes a function of viewing angle. For these reasons, the radar cross-section of a ship must be a composite of many reflectors and the ship must be considered a distributed target.

The assessment models employed in generating a coverage display make the assumption that the target is a point-source target, independent of viewing angle and composed of only a single reflecting surface. While surface-search radars may be employed for the detection of low-flying targets such as a missile or aircraft, their major mission is for the detection of ship traffic. The coverage display *is* appropriate for a surface-search radar's coverage against a small point-source target such as a missile, but the coverage display *is not* appropriate for assessing the detection of ships or other large targets and should not be used in this capacity.

A NOSC Technical Document* describes in detail the use of the coverage and loss diagram and gives guidance in using the loss diagram on occasions where the coverage diagram is inappropriate.

---

*Patterson, W. L. "Effective Use of the Electromagnetic Products of TESS and IREPS," NOSC TD 1369, October 1988.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE August 1990	3. REPORT TYPE AND DATES COVERED Final: July 1990—August 1990

4. TITLE AND SUBTITLE INTEGRATED REFRACTIVE EFFECTS PREDICTION SYSTEM (IREPS) USER'S MANUAL Revision PC-2.0	5. FUNDING NUMBERS PE: 62435N Proj. No. NO1A Task No. RA35G80 Accession: DN888715
6. AUTHOR(S) W. L. Patterson	

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Ocean Systems Center San Diego, CA 92152-5000	8. PERFORMING ORGANIZATION REPORT NUMBER NOSC TD 1874

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Block Programs Naval Ocean Systems Center San Diego, CA 92152-5000	10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.	12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The purpose of this manual is to introduce the contents and operation of the Integrated Refractive Effects Prediction System, Personal Computer Version 2.0 (IREPS PC-2.0). IREPS is a system designed to assess the electromagnetic propagation effects of the lower atmosphere on radar, electronic warfare, communication, and weapon guidance systems. The IREPS models account for effects from optical interference, diffraction, tropospheric scatter, refraction, and evaporation and surface-based ducting under horizontally homogeneous atmospheric conditions.

14. SUBJECT TERMS IREPS ducting electromagnetic path loss propagation atmosphere refraction radio detection and ranging (RADAR)	15. NUMBER OF PAGES
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED	20. LIMITATION OF ABSTRACT SAME AS REPORT

NSN 7540-01-280-5500

Standard form 298

SUPPLEMENTARY

INFORMATION

ERRATA

NAVAL OCEAN SYSTEMS CENTER
SAN DIEGO, CALIFORNIA 92152

15 March 1991

NOSC Technical Document 1874
Integrated Refractive Effects Prediction System (IREPS)
By W. L. Patterson
Dated August 1990

Literature Change

1. Replace the existing pages 29 and 30 with the attached corrected copy.

2. The subject technical document was mailed to you in October 1990.

$T_oT_oT_{ao}\,D_oD_o$ group

T_oT_o – air temperature in whole degrees Celsius

T_{ao} – approximate tenths value and plus or minus sign. Even for plus temperature, odd for negative temperatures.

D_oD_o – depression of dew point temperature

e. standard isobaric surface data groups

xxhhh group

xx – hundreds and tens of pressure surface (i.e., 00 = 1000 mb, 85 = 850 mb, etc.)

hhh – geopotential height (in meters or tens of meters) of the isobaric surface specified

$TTT_a\,DD$ group

TT – air temperature in whole degrees Celsius

T_a – approximate tenths value and plus or minus sign indicator

DD – dew point depression temperature

ddfff group

dd – true direction in tens of degrees from which the wind is blowing

fff – wind speed in knots or meters per second

f. significant isobaric data groups

xxPPP group

xx – number of level above the earth's surface (i.e., 11, 22, 33, etc.)

PPP – pressure in tens or whole millibars

$TTT_a\,DD$ group

same as described for standard isobaric data.

4.2 ELECTROMAGNETIC SYSTEM PARAMETERS

In order to generate an IREPS PC-2.0 product, you must provide the program with various parameters for the EM system. You are solely responsible for the determination of these parameters. For this reason, you are reminded that IREPS PC-2.0 is designed to give relative performance assessments for various systems rather than an absolute performance value for a particular system.

These input parameters may be grouped into several categories, depending upon the system in question. As a training aid, several electromagnetic system files have been provided on the IREPS PC-2.0 distribution diskette. These system files are positioned within the IREPS PC-2.0 default directory structure as defined in section 2.4. The following is a brief description of each system parameter required.

4.2.1 Platform or System Location

There are two options for platform type, namely a SURFACE or an AIRBORNE platform. Surface platforms are primarily those associated with shipboard systems. However, a surface platform could be specified for any system with a transmitter between 3 and 300 feet (1 to 100 meters) above sea level. The primary difference between platforms is that calculations for the interference region are included for surface systems but not for airborne systems. The default is SURFACE.

4.2.2 Transmitters

Over the years, many different types of transmitters have been developed to perform special demands of the radar such as moving target indication (MTI), pulse doppler, continuous waveforms (CW),

phased-array radar, EM compatibility (EMC), and electronic counter-countermeasures (ECCM). The basic demand of the transmitter, however, is to generate power in the form of shaped waves. A number of terms associated with the transmitter are of concern to you:

a. *Frequency.* The frequency must be ≥ 100 MHz (megahertz) and ≤ 20,000 MHz, or ≥ 0.1 GHz (gigahertz) and ≤ 20.0 GHz. The default is 5000 MHz.

b. *Peak power.* Also referred to as pulse power, peak power is the instantaneous maximum power transmitted during a pulse. The peak power must be ≥ 0.1 and ≤ 10,000 kW (kilowatts). The default is 285 kW. **Note:** Peak power should not be confused with average power, which is averaged over the inter-pulse time period during pulse transmission and nontransmission; or with effective radiated power, which is adjusted for antenna gain and transmission line losses.

c. *Pulse length.* Pulse length is the length of time between the start and end of the pulse. Long pulse lengths have the advantage that large amounts of energy can be applied to a target in order to enhance its detectability. Long pulse lengths will lead to the longest range of detection and are therefore used in long-range search radars. Long pulse lengths have the disadvantage that fine details within the return echo will be lost, thereby reducing target resolution. For example, a long pulse length may be used to detect the presence of a harbor within a coast line but cannot be used to detect a pier within the harbor. The pulse length must be ≥ 0.1 and ≤ 9,999 μs (microseconds). The default is 1.3 μs.

d. *Pulse repetition frequency (pulse rate).* Pulse rate is the number of pulses the transmitter generates each second. The prf must be ≥ 1 and ≤ 9,999 pps (pulses-per-second). The default is 650 pps.

e. *Unambiguous range (maximum instrumented range).* After the transmitter sends out a pulse, it turns off and allows the receiver to "listen" for an echo. It may happen that a pulse will travel to a target and back, only to arrive while the transmitter is in the process of sending out another pulse. In such an event, the pulse is not received and the target is not detected. It may also happen that the pulse will return at some time after the transmitter has sent out a second pulse. In that circumstance, the target will appear closer to the transmitter than it really is. Echo signals received after an interval exceeding the pulse repetition period are call "multiple-time-around" echoes. Multiple-time-around echoes are often referred to as "radar ghosts." The range that a pulse can travel to and back in the time interval between pulses is known as the "maximum unambiguous range" or the "maximum instrumented range." The pulse rate is commonly "jittered" or constantly varied so that multiple-time-around echoes will bounce around in range on the display. This variation in range alerts the operator to the true nature of the target.

Often, the maximum unambiguous range will not be available in publications. It may be estimated with the following equation:

$$R_u = \frac{150,000}{prf} \text{ km} = \frac{81081}{prf} \text{ nmi} \tag{1}$$

where *prf* = pulse repetition frequency (pulses per second).

The unambiguous range must be ≥ 0 and ≤ 500 nmi/sm (nautical/statute miles) or ≥ 0 and ≤ 1000 km (kilometers). A value of 0 represents a "not applicable" response. The default is 0.

f. *Assumed system losses.* As energy flows throughout the transmitter, receiver, and antenna system, some of it may be converted to heat, dissipated in the beamshape, or lost in system irregularities, and the system is therefore degraded from the ideal. A single number to account for this degradation is the assumed system loss. It is assumed because there is no practical way to accurately determine total losses. The assumed system loss must be ≥ 0 dB and ≤ 100 dB. The default is 8.4 dB.

30