

Advanced Refractive Effects Prediction System (AREPS)

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INTRODUCTION

In 1987, SSC San Diego provided the U.S. Navy's operational fleet with its first capability to assess the effects of the atmosphere on the performance of electromagnetic (EM) systems such as radars and radios. This assessment system was named the Integrated Refractive Effects Prediction System (IREPS). IREPS was hosted on the Hewlett-Packard 9845 desktop calculator. The EM propagation models of IREPS were semi-empirical and assumed that the atmosphere is homogeneous in the horizontal. IREPS also assumed the earth's surface was water. As desktop computing developed and EM propagation modeling advanced, the various assumptions of IREPS were overcome. In response to a request from Commander, Sixth Fleet during the Bosnian campaign, a new assessment system, the Advanced Refractive Effects Prediction System (AREPS) was fielded for fleet operations.

AREPS computes and displays radar probability of detection, propagation loss and signal-to-noise ratios, electronic-support-measures (ESM) vulnerability, UHF/VHF communications, and surface-borne surface-search radar capability vs. range, height, and bearing from the transmitter.

The power of AREPS derives from its Windows 95/NT interface, making full use of pop-up menus, object linking and embedding (OLE) features such as file drag and drop and graphics export, and extensive online help with color graphic examples.

At the core of AREPS is our Advanced Propagation Model (APM), a hybrid ray-optic and parabolic equation (PE) model that uses the complementary strengths of both methods to construct a fast yet very accurate composite model. Depending on the requirements of the tactical decision aid, APM will run in several different modes. For the full hybrid mode, APM is much faster than PE models alone, with overall accuracy at least as good as the pure PE models. With its airborne submodel, APM can solve problems for very high elevation angles where PE methods would not normally be used.

APM allows for range-dependent refractivity over various sea and/or terrain paths. Not only does the terrain path include variable terrain heights, it may also include range-varying dielectric ground constants for finite conductivity and vertical polarization calculations. APM considers absorption of electromagnetic energy by oxygen and water vapor. APM

ABSTRACT

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accounts for all normal propagation mechanisms, including troposcatter and the anomalous propagation mechanisms of subrefraction, super-refraction, and ducting.

AREPS DISPLAYS

The primary AREPS displays are height vs. range and bearing coverage and path loss vs. height/range and bearing. Figure 1 shows such a coverage display for shipborne air-search radar with its probability of detecting a "small-sized" jet. For this case, the atmosphere is range-dependent, with a surface-based duct existing at the transmitter location, rising to become an elevated duct over the terrain features. To the lower right of the coverage display is a small map, in a simulated plan-position-indicator (ppi) picture format, showing the transmitter location, the display's current bearing, and the terrain heights.

At the top of the display window is a series of buttons that allow you to animate the display in bearing, both forward and backward, to pause the animation, and to obtain a printed copy of the display. Because AREPS is a Windows 95/NT program, the full capabilities of the operating system are available. For example, should you desire to brief the display, you may "copy" the display to the Windows 95/NT clipboard and "paste" it directly into a presentation package such as Microsoft PowerPoint. To obtain loss vs. range and or height displays (Figures 2 and 3), you simply click the right mouse button on the coverage display.

Figure 4 shows the coverage for an airborne transmitter in the presence of an elevated duct; Figure 5 shows the simultaneous surface-based radar coverage and ESM vulnerability; and Figure 6 shows the UHF communication assessment. Note also the three earth surface depictions: dual curved, curved, and flat.

In addition to coverage displays, the effects of radar cross section variability as a function of viewing angle, ship displacement, ship height, and range are combined with the APM capabilities of range-dependent environments and terrain to produce a bar graph display (Figure 7) of detection for five classes of ship targets. These classes range from small (a patrol boat) to a very large warship (aircraft carrier). The viewing angle variability is displayed as subbars within each ship class. These angles are labeled minimum, maximum, and average, corresponding to bow, beam, and quarter.

EM Systems Database

AREPS is an unclassified program and, as such, does not include a pre-established EM system parameter database. Users are solely responsible for creating a system parameter database appropriate to their situation. To assist in this task, a database creation and maintenance capability is provided that uses fill-in-the-blank forms. Figure 8 shows such a form

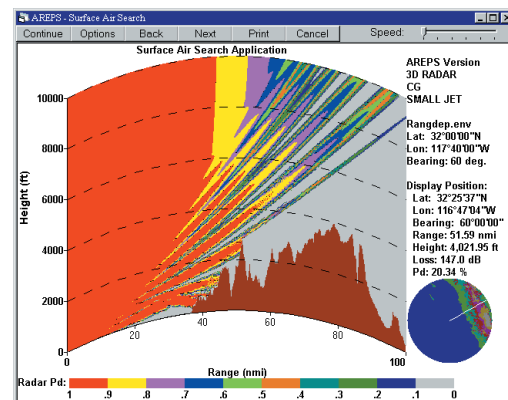


FIGURE 1. AREPS radar probability of detection coverage display.

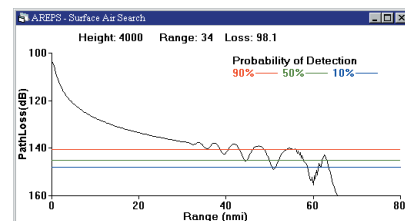


FIGURE 2. AREPS loss vs. range display.

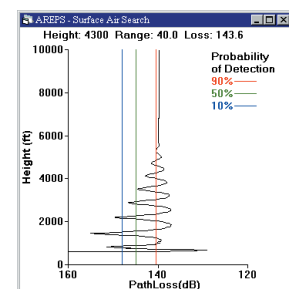


FIGURE 3. AREPS loss vs. height display.

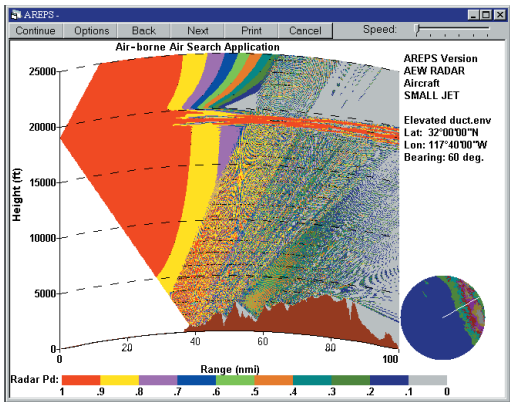


FIGURE 4. AREPS airborne air-search application.

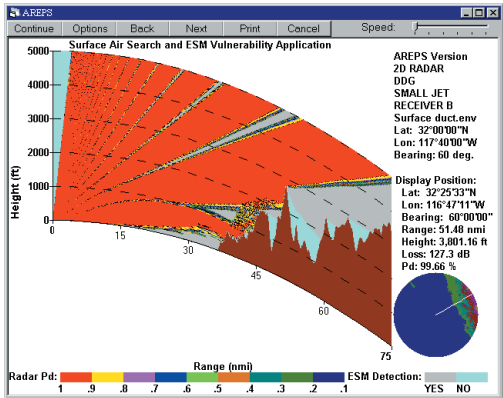


FIGURE 5. AREPS radar probability of detection and ESM vulnerability application.

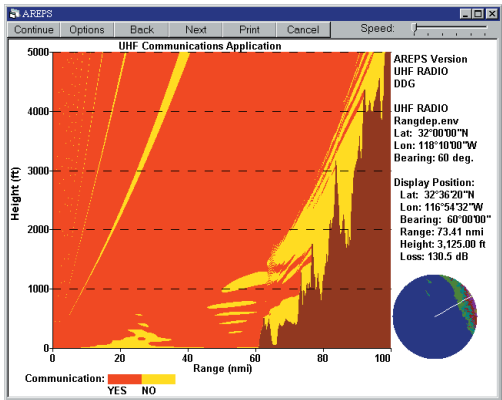


FIGURE 6. AREPS communications application.

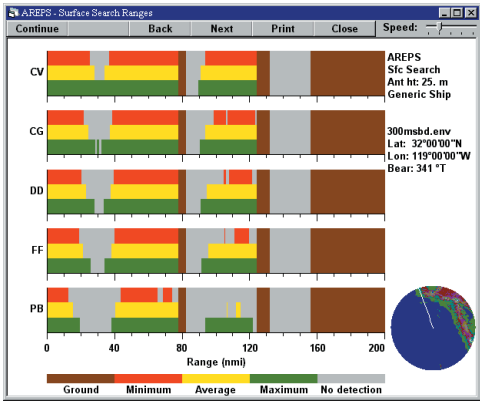


FIGURE 7. Surface-search range tables.

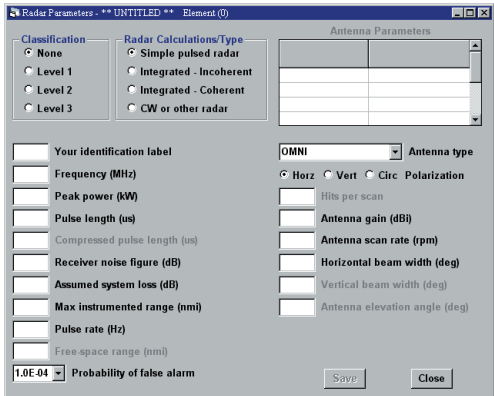


FIGURE 8. AREPS radar system input window.

for a radar system. As one navigates the form, input prompts, parameter limits, and other guidance are displayed in a status bar located at the bottom of the window.

AREPS capabilities include antenna radiation patterns of specific system height-finder antennas and a user-defined antenna pattern. Detection threshold calculations include radars using incoherent and coherent integration techniques.

In addition to pulsed radar systems, users may enter continuous wave and other non-pulsed systems, UHF and VHF communications systems, ESM receivers, and radar target descriptions.

Terrain Data

AREPS derives its terrain height data primarily from the Digital Terrain Elevation Data (DTED) provided by the National Imagery and Mapping Agency (NIMA), available either on CD-ROM or from the NIMA Internet homepage. DTED data are provided in level 0, level 1, and level 2 formats. Level 0 data spacing is 30 arc seconds in horizontal resolution (approximately 1 km). DTED level 0 data are unlimited distribution and may be obtained directly from NIMA's Internet homepage. DTED level 1 data spacing is 3 arc seconds in horizontal resolution (approximately 100 m). Level 2 data spacing is 1 arc second in horizontal resolution (approximately 30 m). Level 1 and 2 data are limited distribution. DTED data are not and may not be distributed with AREPS. For ease of input when using DTED CD-ROMs, users need only specify the latitude and longitude location of their transmitter. The AREPS program will determine which CD-ROM is required, prompt to insert the CD-ROM into the drive, and automatically extract the terrain data needed.

In addition to terrain elevations, the APM allows for the specification of range-dependent surface conditions should users be concerned about surface types for vertically polarized antennas. AREPS uses the surface conditions as defined by the International Telecommunication Union, International Radio Consultative Committee (CCIR). These conditions are provided by plain-language descriptors, selected from a drop-down menu.

Environmental Input

Atmospheric data may be derived from World Meteorological Organization (WMO) upper air observations. The entry of environmental data into AREPS has been completely automated by using the capabilities of the Windows 95/NT operating system. Within normal naval message traffic, WMO-coded radiosonde messages are routinely available. Figure 9 shows such a message.

Users need only locate the message (for a ship, the message is usually available on the ship's local area network); open the message file using any ASCII text

```
FM COMSIXTHFLT
TO OCEANO EAST
USS GEORGE WASHINGTON
USS ARTHUR W RADFORD
USS CONOLLY
USS GUAM
BT
SUBJ/UPPER AIR OBSERVATION //
RMKS/ 1. UUA 77003 99424 10053 18025 99018 17822 29023 00171 18258 31535 92838
16461 32022 85554 13464 31029 70169 05272 31032 50581 13764 29033 40747 25976 30041
30949 421// 30548 25069 // 88999 77999

UUBB 77005 99424 10053 18025 00018 17822 11989 19063 22845 13466 33835 14268
44817 13069 55// // 66771 10467 77754 09667 88// // 99731 08874 11730 08873 22// //
33707 06073 44578 07359 55551 09757 66540 10158 77539 09558 88511 12369 99463 18546
11429 22563 22414 24760 33406 25373 44381 27780 55258 505// 41414 12345 21212 00018
29023 11012 31532 22002 31535 33934 32022 44826 31030 55// // 66718 30528 77496
29034 88258 31049
BT
NNNN
```

FIGURE 9. WMO radiosonde message from Commander, Sixth Fleet.

editor (e.g., Notepad) provided with Windows 95/NT; "copy" the text to the Windows clipboard; and "paste" it into the Import WMO Code window of AREPS (Figure 10).

All extraneous text is filtered; the message is decoded; and a height vs. M-unit profile is automatically created. Should the observation be from a sea-based platform, the surface temperature and humidity are used to calculate a neutral-profile evaporation duct profile, and this profile is appended to the upper air portion of the observation. If surface observations are available, users may override the neutral profile and include full stability dependency.

It is not always necessary to have access to a local area network for the WMO observation. Many shore organizations and ships post their local radiosonde observations on their Internet or SIPRNET (Secure Internet Protocol Router Network) homepage. Once such a homepage is found for the user's particular area of interest, the WMO report may be copied to the Windows 95/NT clipboard directly from the browser (such as Netscape or Microsoft Internet Explorer), and then pasted into the Import WMO Code window. For military users, WMO reports are also available from the Fleet Numerical Meteorology and Oceanography Center (METOC) by using the Joint METOC Viewer (JMV) and/or the METOC Broadcast (METCAST) client.

For those without access to observational data in the WMO format, AREPS contains options to import observational data in a generic column format. Should real-time data be unavailable, AREPS contains a climatology of ducting conditions taken from 921 observing stations worldwide.

With the release of AREPS version 3.0, environmental data may now be obtained from mesoscale numerical meteorological models such as the Coupled Ocean and Atmosphere Mesoscale Prediction System (COAMPS). Thus, for the first time, predictions of systems' performance based on future atmospheric conditions are possible, giving the operator or the tactical decision-maker a valuable tool for mission planning.

Distribution and Support

AREPS is configured for Defense Information Infrastructure Common Operating Environment (DII COE) compliance and has been submitted as a Global Command and Control System-Maritime (GCCS-M) segment. We also provide distribution and technical support for the AREPS program. Distribution is provided on CD-ROM through U.S. mail or by direct download of the program from our Internet homepage (<http://sunspot.spawar.navy.mil>). In addition to the program software, our homepage includes help topics, frequently asked questions, and program service packages.

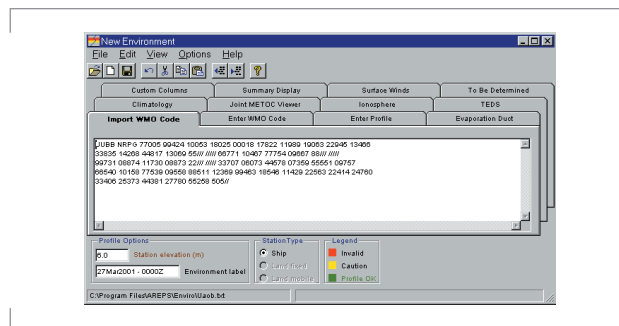


FIGURE 10. Import WMO code tab for new environmental input.



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Current Research: Implementation of advanced atmospheric electromagnetic wave propagation models into fleet operational systems; mesoscale meteorological model interfaces to propagation models.