Radio Mobile

What can it do for you?
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Antenna design is a fascinating subject, and many simulation programs are available. These enable new ideas to be tested out on the computer before actually building a prototype. One thing that has been missing is the ability to simulate a designed antenna for its signal path performance over real terrain. This simulation can now be achieved by using the ‘Radio Mobile’ program.

**Radio Mobile** is a free propagation simulation program written by Roger Coudé, VE2DBE (2). It is based on the Longley Rice Irregular Terrain Model which is useful over the frequency range of 20MHz to 20GHz. Elevation data from the Space Shuttle Radar Terrain Mapping Mission, (SRTM), is downloaded from the USGS site to generate elevation maps of any area, and road maps and aerial photographs can be downloaded and merged as required. Radio Units can be specified for performance and placed where needed on the map, and the characteristics of any Radio Link between any pair of Units examined, complete with a path ground profile.

Elevation data is available for the whole world between ±60° Latitude at 3-arcsecond (90m) resolution, and North America has the advantage that 1-arcsecond SRTM (30m) data is also available.

The program is supplied with a set of generic antenna patterns, but User 3D antenna patterns can be produced using my spreadsheet, and then allocated to a particular radio Unit for use in coverage plots. Coverage plots can be performed using S units, dBm or µV relative to the receiver threshold setting or in dBµV/m at a height determined by the receiving Unit ‘Radio Operating System’ specification.

I have used the program extensively since the USGS released 3-arcsecond world wide SRTM data in November 2003. Before that time only 30-arcsecond data was available, with a height matrix of 1km resolution which couldn’t define our valley folds in any detail. My main use for the program is in the planning of our Radio Amateur Emergency Network (Raynet) exercise UHF repeater locations in the UK Peak District. I have also generated a portfolio of coverage plots for the repeaters when placed in 24 hour accessible car parks in the Peak District for Raynet. This enables us to determine a suitable repeater location quickly for any area coverage in case of an Emergency call out.

As a demonstration of some of the features of the program, the following screenshots have been produced by a modified version of my ‘Base Network’ located in the UK Derbyshire Peak District. This particular Network is generated directly by my Installer (1), which produces the working program – the network generated can then be easily moved to any other location in the world, with new radio Units and Radio Operating System specifications as required.

First, an elevation map of my area was produced, with the height of the map selected as 30km, and the screen size as 1100x700 pixels to fit my monitor screen. A
The road map was then downloaded and converted to greyscale in the program, and then merged in multiply mode with the elevation map to produce the screen below.

Three radio Units are also shown located on the map. These are operating using the following ‘Radio Operating Systems’ to define each Unit's performance.

<table>
<thead>
<tr>
<th>Base UHF System</th>
<th>Mobile UHF System</th>
<th>HH UHF System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>Frequency</td>
<td>Frequency</td>
</tr>
<tr>
<td>420-440MHz</td>
<td>420-440MHz</td>
<td>420-440MHz</td>
</tr>
<tr>
<td>Tx Power</td>
<td>Tx Power</td>
<td>Tx Power</td>
</tr>
<tr>
<td>10 watts</td>
<td>10 watts</td>
<td>1 watt</td>
</tr>
<tr>
<td>Rx threshold</td>
<td>Rx threshold</td>
<td>Rx threshold</td>
</tr>
<tr>
<td>0.25μV</td>
<td>0.5μV</td>
<td>0.5μV</td>
</tr>
<tr>
<td>Line loss</td>
<td>Line loss</td>
<td>Line loss</td>
</tr>
<tr>
<td>1dB</td>
<td>0.5dB</td>
<td>0dB</td>
</tr>
<tr>
<td>Antenna</td>
<td>Antenna</td>
<td>Antenna</td>
</tr>
<tr>
<td>Yagi</td>
<td>Omni</td>
<td>Omni</td>
</tr>
<tr>
<td>Ant. Gain</td>
<td>Ant. Gain</td>
<td>Ant. Gain</td>
</tr>
<tr>
<td>17.15dBi</td>
<td>4dBi</td>
<td>2dBi</td>
</tr>
<tr>
<td>Ant height</td>
<td>Ant height</td>
<td>Ant height</td>
</tr>
<tr>
<td>8m</td>
<td>2m</td>
<td>1.8m</td>
</tr>
</tbody>
</table>

To examine the ‘Radio Link’ between the Base Unit and the Hand Held radio, the appropriate toolbar icon can be selected. This has two effects, first the Radio Link pane opens, and second the path between the Units is shown on the main display. The colour of the radio path indicates the signal strength compared to preset ‘Style’ settings. These settings are made relative to the receiver sensitivity, with an intermediate band of signal levels being shown as yellow for ±3dB, >3dB as green, and <3dB showing red.

A small antenna pattern is also shown on the main screen round the Base icon, illustrating that the default Yagi antenna is in use with its azimuth, and the green path shows that the signal exceeds the preset upper level.
Now considering the Radio Link pane in detail, this gives a summary of the preset operating Systems for both ends of the link. The top green/yellow data area enumerates path loss and signal levels in all units, plus the location of the obstruction giving the worst Fresnel clearance. The distance from the transmit Unit to the pane cursor is displayed, and this cursor can be placed at the obstruction using a click on the data area. Below the profile area are two bar graph signal level indicators, the one in the transmitter area showing the calculated reverse path signal levels.

The position of the cursor on the Radio Link pane can be selected by a click on the ground profile area or by using the arrow keys. This position is reflected on the main window by the red cursor cross wires.

Both the transmitter and receiver antenna heights can be adjusted from their operating System values to check the effect on propagation, with an Undo button to return to the System values if required.

Azimuth and Elevation of the transmit path are both shown, and a control button allows the path direction to be Swapped – this is indicated by the Unit names and a direction arrow shown on the main window.
A click on the transmitter section ‘Antenna gain’ line ‘+’ button opens an antenna pattern viewer pane. Here we can see the settings and antenna used, with details in the lower left data area. The Yagi was set to point at the HH radio Unit.

Selecting the Vertical check box displays the vertical antenna pattern, the purple line again showing the signal path direction.
Next, if the receiving Unit on the Radio Link pane is changed to the Mobile, it can be seen that the ‘Rx relative’ text has changed to red, as has the path indication on the main window as the lower signal limit was set to <3dB relative.

Looking at the small transmit antenna pattern on the main screen gives an indication of the problem. A click on the Transmit ‘Antenna gain’ line ‘+’ button, opening the pattern Viewer, then shows:
With the yellow azimuth pattern having a purple signal path azimuth line superimposed – selecting Vertical pattern shows the available gain in brown, and gain achieved in yellow, again indicated in the lower left data area.

One addition function of the Radio Link pane is the capability to export its data, first to a Text file, second to a built-in program RMpath. In RMpath the options allow more Fresnel zones to be displayed, and it opens with the pane cursor at the obstruction as shown. This pane can be resized to suit.
The final export function is to Google Earth, where selectable Fresnel zones can be displayed, and the actual path explored using the Google Earth 3D functions.

Other functions of the Radio Link pane allow the receiving Unit to be viewed from the transmitting Unit – if this is performed over an ‘elevation referenced’ aerial photograph, the following view can be generated. In this picture the receiving Unit is visible from the transmit antenna position, and this is indicated by the small white circle in the middle of the horizon.

The final indication of an antennas performance in the real world can be obtained by generating radio coverage plots. In the following plots, the Base Unit with its fixed Yagi antenna is used as the source, and the mobile – moving – Unit is selected as the Hand Held radio. With both plots an antenna pattern is shown for the source Unit, measurement unit is μV, and they are performed over a greyscale elevation referenced road map.
This first plot is performed in a Polar manner. In this case the minimum and maximum radial range and angles of plot are specified, and the plot is performed in a radial manner in specified decimal degree steps. This is a very quick plot to perform, and can be used for the central Unit as transmitter, receiver, or display the ‘Worst case’ two way transmission characteristic over the defined area.

The only drawback of the Polar plot is that as it is performed in decimal degree wedges, the areas for signal averaging increase as you move out from the centre point. Thus, the accuracy is lower at the outside of the plot than near the centre.

The plot has been performed in ‘Rainbow’ mode, where the selected colour pallet and signal range is shown on the legend. It is also possible to perform a single colour plot where a region having a particular signal range is indicated.

The variable area accuracy problem doesn’t arise with the Combined Cartesian plots shown below. In this case the plot areas are defined in ‘pixel squares’, so the accuracy is constant over the whole map, and the plot is performed in an X-Y fashion. It should be borne in mind however, that the time to perform a 10x10 pixel area plot resolution is increased by 25 times if the plot is performed at 2x2 pixel resolution.
There are many advantages in using the combined Cartesian plots due to their versatility. One feature which is available is demonstrated below – an optional signal (SIG) file can be generated during a plot calculation. This file will be saved with any plot picture for later use, and the feature generates a calculated signal strength reading for each plot pixel area under the cross wire cursor. This signal level is reported at the end of the left data area at the bottom of the main window.

The signal level can be seen to be $S=44.93\mu V$, with the cross wire cursor placed in a yellow banded area which indicates a level range of 39$\mu V$ to 63$\mu V$. This feature allows the coverage patterns to be explored in detail after they have been saved.

Other facilities available with the Combined Cartesian coverage feature include coverage plots of zoomed areas of the map, finding the Best Unit for coverage of an area, the Best Site to cover many locations plus the ability to perform Route Radio coverage. In this case a Route is drawn on a map, and locations can be identified which will provide radio coverage of that route.

One additional feature which hasn’t yet been mentioned is that with any of the path calculations Land Coverage data can be incorporated. In this case the buildings or foliage type, density and height along the path are examined, and their influence on the transmitted signals estimated and incorporated in the results. As an indication of the effect, the Base to Hand Held Radio Link pane is shown below where Land Coverage has been incorporated.
A representation of the coverage can be seen on the ground profile, and an additional line of data inserted into the data area giving additional Urban, Forest and Obstruction loss values.

The program is at V9.9.2 in May 2009, and my installer will generate the most recent English version. It is available in 10 languages, and my installed version can easily be changed to a different language. Updates can be obtained directly from the program via the web. The RM Group on Yahoo (3) currently has over 6000 members, with 8600 messages to browse for answers to queries.

**Conclusion:**

So we have here a free radio propagation simulation program, with so many features enabling you to explore the performance of your experimental antenna designs over real terrain profiles – and much more!

Give it a go – I did, and found it to be an awesome piece of software! -30-

References:

1) Radio Mobile Installer and Tutorial  
   http://www.g3tvu.co.uk/Radio_Mobile.htm
2) Radio Mobile Home page, Roger Coudé, VE2DBE  
   http://www.ve2dbe.com/english1.html
3) Radio Mobile Yahoo Group  
   http://groups.yahoo.com/group/Radio_Mobile_Deluxe
BRIEF BIOGRAPHY OF AUTHOR

I gained my Amateur Licence in 1964, and after moving to RR really started operating mobile on my journey to work. I have contacted over 220 countries whilst mobile on 14MHz from my vehicles during that 17 mile journey, and I have missed the operating since I retired.

My major work was in Radio Telemetry systems, extracting data from the inside of working aero engines, and covered the design of the transmitters and power transfer systems to achieve this. It could be described as 'Harsh environment telemetry' as the rotating components had to work at 125C and 45,000g as some were mounted on the HP spool! I even had a TV camera operating at 6,000g and transmitting pictures out of a rotating test rig.

The other things we did - for your information - was to fire a salvo of birds at 270mph into working engines for bird ingestion testing, where the control of the firing and 20,000fps high speed cameras were all part of the project. We also did Blade containment testing for certification, where I blew a fan blade off a working engine with cutting explosives and filmed the results! Real Boy's toys, where pressing a button allowed 60,000HP to drive a 90ton out of balance fan disk round at 3000rpm and film the result. (It did wreck an engine at a cost of £15M for the test, but was required for certification.)

As I had a great time in my school 'Combined Cadet Force' RAF section, I decided to give something back when we settled in Ashbourne, and joined the local school CCF as Signals officer to provide radio training. This led to me becoming a Troop Cmdr. in our Territorial Army Royal Signals for a number of years, where I had an area of 5 counties to cover with mobile HF communications detachments. I continued with the CCF, retiring about a year ago after 30 years service with the honorary rank of Major (Retd)

From the notes on Radio Mobile you can see that I am still involved with our Emergency planning for exercises - and I still have an Army callsign to help on the Cadet Forces National Radio Network when required.

So, 68 and going strong - I don't know how I found time to go to work. Still fascinated by antennas though!