Modelling Radio Amateur Repeater Coverage

by

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1 Introduction

Powerful computer software is available nowadays which allows predictions to be made of the coverage from radio transmitters with defined parameters.

The prediction can be made over a given data terrain model (DTM or DEM) which will have a resolution, typically 50 or 100 metres.
Whilst computer generated maps are used in the vetting process for amateur repeaters, the maps shown on ukrepeater.net are for indicative purposes only and show what typically might be expected from that station for "typical" station parameters (if there is such a thing in amateur terms!)

The licenced computer software used for carrying out coverage predictions for the RSGB Repeater Management Committee is ICS Telecom/HerTZ Mapper and both licenced OS digital mapping (planning and internal use) and public domain digital mapping (web)

2 TX technical parameters:

Site (location in NGR or lat/long) as accurate as known for best results.
Example of input could be in format NS828647
Frequency (generic band frequency if channel not known)
Power to antenna (specify if Watts or dBW as confusion sometimes occurs!)
Antenna details (height, gain, azimuth and directivity)
Losses (cumulative effect of feeder, combiner and duplexer losses must be known before the ERP can be determined)

3 Operator characteristics.

This is the difficult bit, as amateur stations vary so greatly.
Generally for amateur speech repeaters a receiving height of 1.2 metres above ground level is taken, and a unity gain (0dBd) receive antenna is used. This is because repeaters are designed for mobile and handportable rather than fixed station use.
Note that for amateur television scenarios, a height of 4 metres above ground and a minimum receiver gain of 12dB is used.
It is assumed that the base station receive threshold will be set as low as possible, typically 0.3μV into 50ohm, but the user handportable or mobile squelch will be set a little lower possibly towards 0.2 microvolt.
Some base stations require a higher squelch setting due to de-sensitisation or a high noise floor that occurs at some larger commercial sites.
Likewise a user sensitivity may be set lower if in fixed mode and higher if mobile.

4 System Settings

Once a set of "acceptable" site and operator parameters has been determined, a path budget analysis is set up.

This examines the path losses on the downlink (from base station to user) and the uplink (from user to BS) If there is a discrepancy in the path budget, then the worst path (weakest link) is taken as the working figure.
It is then possible to work out a minimum threshold for the system which will represent 50% locations for 50% of the time.
This is not normally accurate enough when requiring to know level of service, so an uplifted threshold will typically be used to represent 90% of locations, and is a more reliable figure on which to plot coverage and indicate a "strong likelihood" of coverage.
A further uplifted figure may be shown to represent handportable coverage and will take into effect losses taken for body worn equipment and the typically lower power used by the operator.

Amateur stations, by their very nature, vary considerably from equipment used, power and operating conditions. This is particularly difficult for the task of setting coverage prediction parameters.

When a computer simulation provides a field strength for a particular location, a degree of uncertainty will exist about the actual level which will be encountered.
Bear in mind that the propagation path will vary depending on such things as atmospheric conditions, obstructions and other features. An important step in interpreting simulations is to understand the relationship between the single (median) value produced by the model and the spread of signals that will be experienced in those locations, and this is governed by a probability distribution, for example Log Normal.
If "Log Normal" distribution is used, then there is a 10dB difference between 50% probability and 90% probability of locations coverage. This 10dB is used as an "uplifted" receive threshold and will show a smaller coverage footprint, but one in which there is a stronger probability of coverage.
Likewise if 99.9% is required then another 20dB should be added to the 50% figure.

There are many different types of propagation algorithm that have been developed to predict the effect of a radio wave between transmitter and receiver. They have applications over specific frequency ranges and type of radio network.

There are two broad types of model, those determined by physical situations (deterministic) and those derived from measurements (empirical)
For example the *Okumura-Hata* model which is primarily used to model urban coverage at UHF is based on complicated formulae and three categories of path; urban, rural or suburban.
The *ITU Recommendation P525/6* is a deterministic model which allows for diffraction and sub-path losses to be included.

Many of the indicative maps seen in ukrepeater.net and those used in repeater planning use the *ITU525* model with clutter *EBU* attenuations, and *P526 Deygout* diffraction geometry.
Note that the more common *CCIR* clutter attenuation was found to be too severe for amateur situations, if clutter is used at all then the published *EBU* clutter is used as a compromise setting which could be reproduced.

5 Thresholds

As repeaters at 2M and 70cm are designed for mobile and handportable station use, all maps assume this mode of operation and make an estimate at other parameters.
A number of different thresholds have been experimented with in an attempt to more accurately show repeater useable coverage.
These parameters are varied depending on information available and in particular cases, but a set of parameters is shown below that is used on maps used for vetting purposes.

29 MHz and 50 MHz

Field strengths of 14dBμV/m and 24dBμV/m are used.
In some cases a single threshold of 14dBμV/m is shown for convenience.

2 Metres

After a considerable amount of experimentation a "set" of thresholds has been "standardised" as representing the best compromise for the widely varying user configurations:
14dBμV/m (often shown as magenta) is used to represent a 90% likelihood of mobile service under typical conditions.
24dBμV/m (often shown as blue) is used to represent a 90% likelihood of handportable reception, and 99% mobile.
In the early planning stages for a repeater it was found to be useful to show a lower threshold then 90% service especially to demonstrate the potential for interaction with other repeaters.
Figures of either 7 or 10dBμV/m (often shown as green) have been used for this purpose, but do not appear on web maps.

70cm

A similar "compromise" was used to represent coverage on this band.
24dBμV/m (often shown as magenta) is used to represent a 90% likelihood of mobile service under typical conditions.
32dBμV/m (often shown as blue) is used to represent a 90% likelihood of handportable reception, and 99% mobile.
In the early planning stages for a repeater it was found to be useful to show a lower threshold then 90% service especially to demonstrate the potential for interaction with other repeaters.
Figures of either 14 or 20dBμV/m (often shown as green) have been used for this purpose, but do not appear on web maps.

23cm (speech) repeaters

Various thresholds have been used to represent voice repeaters on this band.
20dBμV/m (green)and 30dBμV/m (blue) have been used after some trials, but in single threshold maps, 24dBμV/m has been used especially in no-overlap network mapping.

Television bands

Various thresholds have been used to represent voice repeaters on this band.

30dBμV/m (magenta), 40dBμV/m (green) and 50dBμV/m (blue) have been used after some trials, but in single threshold maps, 30dBμV/m has been used especially in no-overlap network mapping.
In the case of television repeaters a height above ground level of 4 metres is assumed and a receive antenna of 12dB used.

6 Service to applicants

The Proposals Manager of the RSGB Repeater Management Committee carries out coverage plots to repeater engineers, planners and groups on request. These maps can subsequently be used to support repeater applications.
The ETCC web site http://www.ukrepeater.net/ shows repeater coverage maps but shown against lower definition backdrop maps to reduce file size and for copyright reasons.