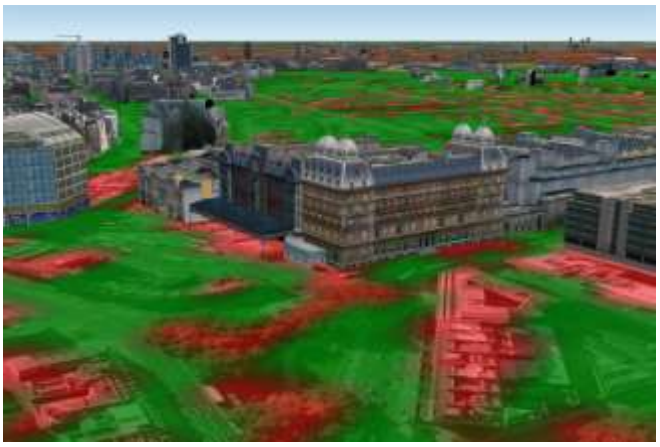
New Approaches to PMR Planning

Abstract: bands used for private mobile radio (PMR) are becoming increasingly congested, particularly in urban areas. The key questions are: what is the coverage and can spectrum be time-shared? Recently Transfinite has undertaken research into this subject, and some of the points identified are described in this white paper.

PMR Communications

What does “mobile communications” mean to you?



A mobile handset can be used to access a range of services within an equally wide range of industries.

While it is often used with one of the networks provided by the publically available operators, it can also mean a closed communication service used by a single organisation. It could be a taxi company, the base issuing instructions to the drivers, or it could be a shopping centre, with guards communicating via push to talk services. This type is what we will call private mobile radio (PMR) though it is also known as business radio (BR).

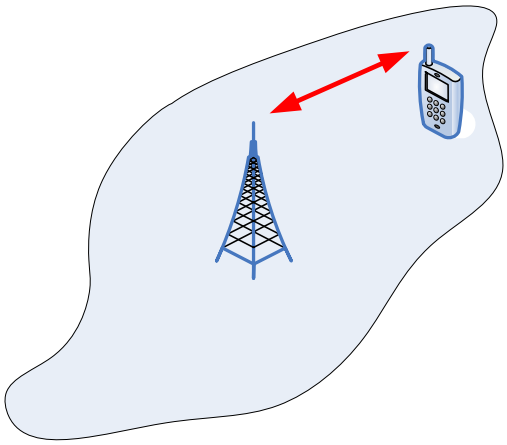
Recently Transfinite has undertaken research to study coverage of PMR networks and develop new ways to undertake rapid and accurate analysis.

Private Mobile Radio

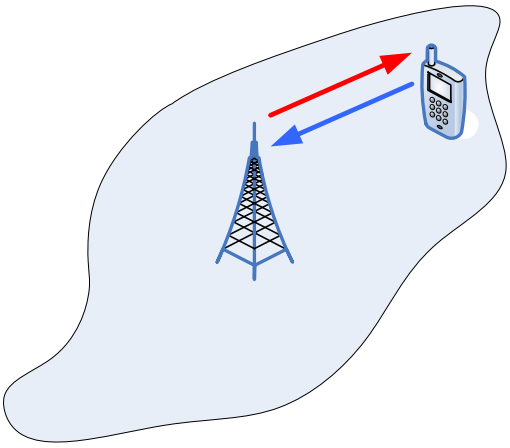
PMR is used in a wide range of industries including construction, retail, transport, and public services including the emergency services.

PMR can be licensed on a site by site rather than national basis, and this requires the regulator to manage the spectrum to ensure that licensees have the coverage they require and meet a suitable quality of service (QoS) metric.

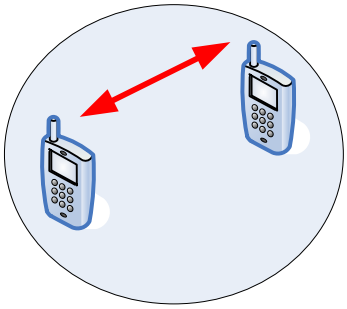
There are a number of types of PMR, of which the most common are shown in the figures below:



Simplex: single frequency used for the base station to mobile and mobile to base directions



Duplex: different frequency used for the base station to mobile direction than mobile to base



On-site: single frequency used for mobile to mobile communications

The range can vary from 1 km for an on-site system to a radius of tens of kilometres (60 km in the UK) for a wide area duplex system.

To ensure the system provides the required QoS it is necessary to check both that there is sufficient coverage and also that it is compatible with other PMR assignments. There are two main mechanisms that one PMR system could degrade another:

- Interference, by decreasing the C/I margin
- Blocking, by occupying the channel

In a lightly occupied band it is possible to avoid blocking by ensuring there is no overlap in coverage between different PMR systems.

However in areas where there is high demand – such as central London - this can lead to spectrum inefficiencies. Many PMR systems only require access to the radio channel for a portion of the time and so it is feasible for PMR systems to have overlapping coverage if the impact on their QoS is acceptable.

Some PMR systems require a high QoS – in particular the emergency services will require exclusive access to ensure the channel is always available. However other services could accept a shared channel, and this degree of sharing can be parameterised using two values:

- Activity factor (AF): how likely is it that a system will be using the radio channel
- QoS threshold: what is the maximum degree of sharing that is considered acceptable

The question is then how to use these parameters to evaluate whether a proposed new PMR system is compatible with existing assignments.

In the UK this algorithm is called the Mobile Assignment Technical System (MASTS) which Transfinite analysed and implemented in our software tools.

MASTS Algorithm

When an application for a new PMR system is received there are a series of tests that must be made:

1. Are the parameters in the acceptable ranges?
2. Can the requested coverage be achieved?
3. If the PMR requires exclusive access to spectrum, is the interference at the coverage boundaries below the threshold?
4. If the PMR can share spectrum, is the blocking metric below the QoS threshold?

Note that the interference and blocking checks in steps 3 and 4 must be considered in two directions, namely from/to the new assignment to/from others.

These checks are complicated by the combinations possible with the range of different PMR types, so there could be cases that involve:

a) Base transmit into base receive

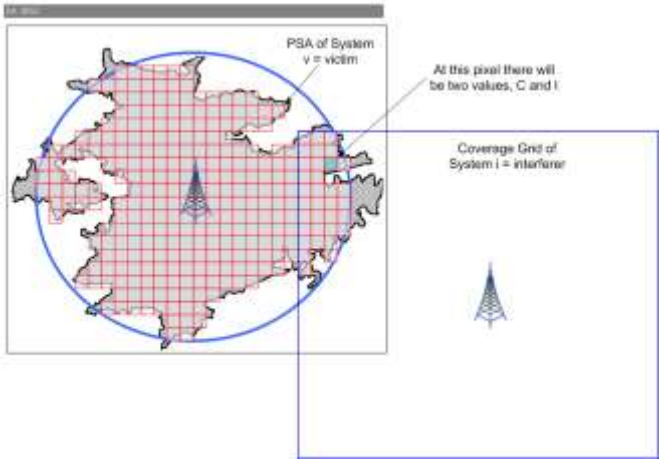
b) Base transmit into mobile receive

c) Mobile transmit into base receive

d) Mobile transmit into mobile receive

For each of these cases different approaches can be used to assess likelihood of blocking, for example:

- In case a) if the signal received is above the blocking threshold, then the likelihood of blocking is the AF
- In cases b) and c) the likelihood is ratio of the overlap of the coverages (as shown in the figure below) multiplied by the AF



- In case d) Transfinite proposed a change to the MASTS algorithm to calculate the blocking probability using a Monte Carlo methodology taking into account the AF

The calculation should also take account of factors such as the power used by each of the transmitters, bandwidth adjustments and whether they are indoors or outdoors.

P.1546 vs. P.1812

The most important factor in the calculations of compatibility is the propagation model and its associated database(s) of geographical information.

One of the most commonly used propagation models for planning PMR systems is defined in Rec. ITU-R P.1546, but it does have a number of limitations including:

- It is unable to handle the case when the base station antenna is below the local clutter level
- It is unable to handle the case of mobile to mobile radio paths

- It only partially uses terrain data
- It is unable to handle detailed surface data that models urban areas on a building by building basis.

For this reason there has been significant radio propagation research into new models resulting in Rec. ITU-R P.1812 which overcomes these limitations.

However the predictions can be significantly different as can be seen by the following example coverage plots:

TX antenna above clutter using P.1546 at VHF

TX antenna above clutter using P.1812 at VHF

TX antenna below clutter using P.1546 at UHF

Map images © Google and associated companies

TX antenna below clutter using P.1812 at UHF

Surface Data

One benefit of P.1812 is that it can predict coverage using high resolution surface database.

For the project Transfinite had access to a 3m resolution database of central London that identified buildings and streets as shown below:

This data could be used to give a detailed coverage prediction but also required much more accurate inputs – in particular the location and height of the transmitter with respect to the surrounding buildings.

There were therefore implications on the wider licence application and management process in terms of data capture and storage.

In addition this greater resolution requires finer pixels which means additional computational and storage requirements.

Transfinite's Solution

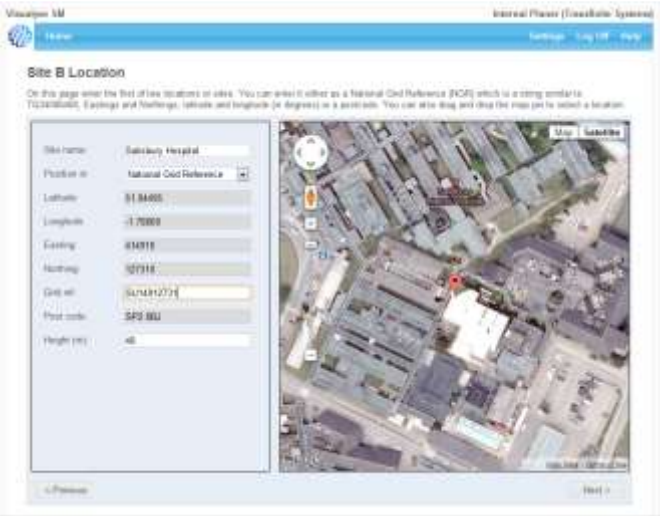
The analysis identified a number of issues that an advanced PMR assignment tool would have to address, including:

1. Ensuring the location data is captured accurately without putting excessive burdens on the end user
2. Handling the computational analysis within a reasonable time frame

The approach proposed by Transfinite would solve both of these two key issues.

Transfinite's Visualyse Spectrum Manager was developed to be a web based licensing portal, and it showed how it can be made easy for users to enter their location data to a high degree of accuracy.

This solution employed the latest web based mapping technology so that locations could be looked up via postcodes and then specific buildings identified by moving and dropping a pin as in the figure below:



The surface database can also be used to identify antenna heights, as it can be defined using the easier to judge height above roof-top rather than above terrain.

The computational approach was again to split the task of predicting coverages and analysing QoS into jobs which could then be farmed into multiple threads. By using this approach fine resolution grids could be generated using high resolution terrain and surface data within reasonable time frames.

Result

Our proposed approach would ensure that PMR bands are managed in an efficient manner, taking advantage of the latest technology and radio engineering techniques, including surface databases, Monte Carlo methodologies and parallel processing.

How we can help

We can help operators and spectrum managers analyse mobile coverage including:

Consultancy Work

Our consultants can assist you by undertaking:

- Studies of compatibility and methodologies
- Analysis of mobile network coverage to meet regulatory obligations
- Support for mobile network backhaul planning
- Management and analysis of planning of bands for private mobile radio
- Link design and radio spectrum planning

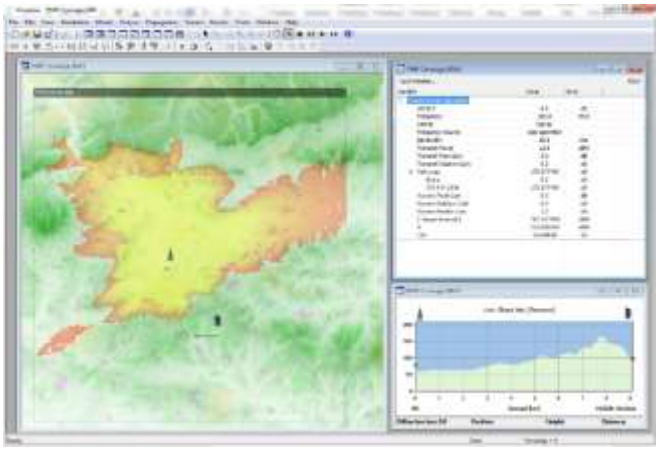
Regulatory Support

- We can provide a range of services to support regulatory activities including licensing and representation at international and regional meetings (e.g. ITU and CEPT).
- We have experience in spectrum auctions and trading, together with operating as a spectrum management organisation (SMO).

Visualyse Professional

Our desktop study tool Visualyse Professional can be used to analyse radio systems including link planning, coverage and interference analysis.

This can analyse almost all types of radio system including mobile, fixed, broadcasting plus other services that might have to share spectrum such as satellite earth stations.



Contact us

If you have any questions or comments about this White Paper or would like more information please do not hesitate to contact us at:

Email: info@transfinite.com