

■ **White Paper**

Deterministic in-filling of mobile networks in urban areas

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Deterministic In-filling of Mobile Networks in Urban Areas

This write up outlines ATDI's competence and tools used to fill in mobile network coverage. This paper augments the papers and Powerpoint presentation completed showing how fill-in can be achieved for railway coverage gaps.

The Problem

The mobile network in this example city uses three sites (shown as small green dots) and exhibits poor performance in the clear area (about 1km across by 1km high). The display shows that within this area the rooftops of the buildings are covered however the streets are poorly covered. This example city has been used since this data set has all the layers needed for the computation. The method outlined applies to anywhere.



Figure 1: Existing Network Coverage

The problem is assumed to be primarily coverage (as opposed to traffic, handover, capacity or interference) although the method can be adapted to accommodate those effects.

Objective

The area shown is urban comprising buildings from 5 metres in height up to 50 metres. The buildings and terrain are described by a 1 metre resolution digital elevation model. Lower resolution data can be used for 900MHz planning and 10 metre resolution would be adequate.

The objective of the deterministic coverage exercise is to provide a) street coverage at the foot of the buildings and b) in-building coverage. These two objectives will be handled separately.

The Data Layers

Figure 2 shows the digital elevation model describing terrain and buildings. This example digital elevation model includes vegetation heights. If the vegetation heights were not included a second layer describing the vegetation would be required and with it appropriate clutter losses or heights to be applied to the layer.

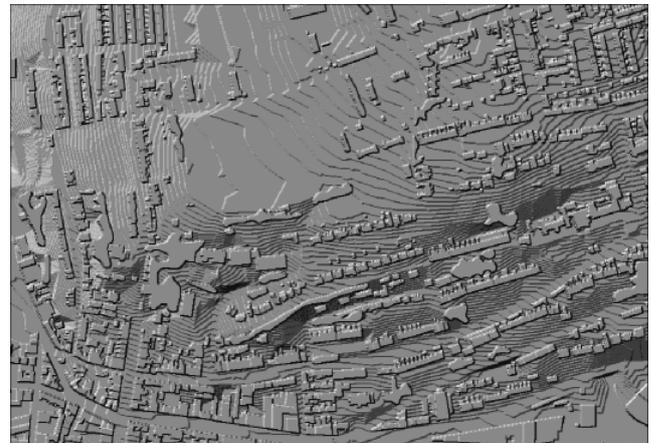


Figure 2: Digital Elevation Model

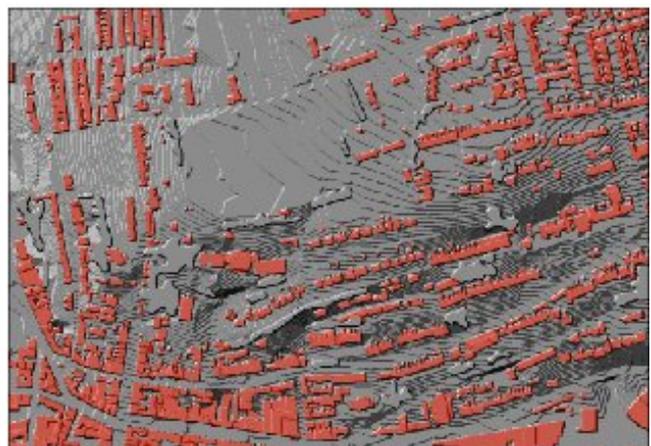


Figure 3: Rooftops Definition

Figure 3 shows a further layer that is needed for the street level coverage and this is shown as an expression of rooftops. This shows rooftops in red, matching the building height objects. All other non-coloured areas are streets and open spaces and also vegetation. Vegetation can be filtered out using the vegetation definition in the clutter layer.

A fourth data layer is needed for indoor coverage and this is shown below describing 'indoor' and 'deep indoor'. These classifications correspond to work completed under programmes such as COST 231.

Process for Street Coverage

The aim is to determine where one might place a base station to enhance the coverage to street users within the area identified.



Figure 4: 500 Subscribers On the Ground in the Streets

Some 500 subscribers are placed on the ground in the streets and in the open areas.

An automatic plan can then be prepared effectively reverse planning from each subscriber at 900MHz seeking coverage to a given field strength. ICS Telecom will then indicate where the best location is to serve a majority of these randomly placed subscribers.

Propagation Model

The propagation model used in this example is a Free Space model with diffraction. Each building is considered a diffraction edge and the Deygout multiple knife edge diffraction model with up to 1000 diffraction edges has been used to prepare a detailed prediction. The path profile for a path from one of the subscribers to the base station that the auto-planning exercise placed.

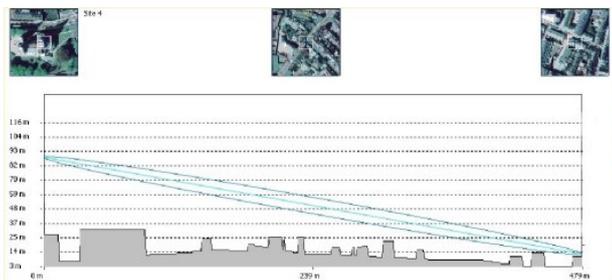


Figure 5: Profile from Rooftop Base Station (left)

The result of the auto-planning is shown below. A single site is shown to cover the area. Some 498 of the 500 subscribers are covered.



Figure 6: Result of Auto-planning Showing Site Suggested

The final result of this auto-planning is shown below. There are still two points that have not been covered to the North East of the area but the design meets the expressed target coverage.



Figure 7: Final Coverage Resulting from Auto-planned Site

Note that whilst this scenario has suggested a new site, it may also be used to evaluate a limitless list of candidate sites or potential site locations (referred in cell planning as 'search rings').

Expanding to In-building Coverage

In-building coverage can be modelled by adding an excess loss over the 'normal' propagation model to allow for penetration loss. This is an inexact science since penetration loss does depend on building construction, the depth to which penetration is needed and the angle at which the wave strikes the building. The intensity of the signal on the building wall will also vary with height above the street. The median signal level deep indoors on the second floor facing away from the cell site is therefore different from that on a facing wall on the first floor with only a window to penetrate. Nevertheless, the method here is the only real way to model the scenario with reasonable time and money spent on the



data.

The blue editing of the rooftop file marks deep indoor (locations within the building >10 metres from an outside wall). The red/brown (the original rooftop data) marks those rooms within 10 metres of an outside wall. Each clutter value is given a penetration loss – at 900MHz, deep indoor will be of the order of 25dB and just indoor, around 17dB. Values of penetration loss will be taken from COST231 and can be transferred automatically to all subscribers within each pixel. The data layer needed to express indoor classifications can be generated automatically using ATDI software.

The process outlined above can be repeated spreading subscribers just indoor and deep indoor. The penetration loss will be taken into account and base station locations suggested to cover the subscribers. The categories of deep indoor and just indoor can be expanded to add further categories with new losses.



Figure 8: Modification to Rooftops to Describe Deep Indoor

Methods for Multiple Floors

The worst case will always be coverage to ground floor rooms. All coverage can therefore be modelled allowing an excess loss over the street median. That said, it may be that upper floors are to be considered or even that coverage to underground car parks and the like is needed. These are separate scenarios and can be repeated simply allowing a height gain (as a decibel value) over the street median to be subtracted from the penetration loss. An alternative is to repeat work with high subscribers. With this done the automatic planning for other floors can be accommodated.

Expansion to Geospatial Weighting

Because the gap in coverage is now an area rather than a line (as was the case in railway in-fill), producing reverse coverage plots to replace the subscriber modelling used above takes an order longer. This is a logical progression however and geospatially weighted plots showing the optimum locations for sites can be produced in the same way as for railways.

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