Historic cell site analysis – Overview of principles and survey methodologies

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A B S T R A C T

The data stored on mobile phones is a common source of investigative and evidential material, but there may be further useful information available such as Call Detail (or Data) Records linked to the SIM card used, held by network operators for billing purposes. Historic Cell Site Analysis involves the analysis of these records, in conjunction with other information such as survey and geographic data, to determine areas where a phone may, or may not, have been when it was used.

This paper gives an overview of how a handset and mobile phone network interact with each other along with a range of methodologies for data gathering and interpretation (including use of surveys). These methods are assessed, with advantages and disadvantages highlighted for each. Only 2G networks are discussed in detail; whilst there are differences in many aspects of network operation, general principles (such as the effects of terrain and relative cell selection) apply equally to 2G (GSM) and 3G (UMTS) phone networks.

Live Cell Site Analysis (locating a mobile phone in real time) is not covered.

¹ www.forensic.gov.uk.

1. Overview of a typical mobile phone network

1.1. Call Data Records (CDRs)

The CDRs encountered by Law Enforcement Agencies are subsets of information produced and stored by mobile phone network providers and (like Call Billing Records which are derived in a similar manner) list calls and texts made from, and in some cases to, a particular mobile phone number. Other information available may also include use of MMS or other data services. The CDRs list information including the time and date of the call, the phone numbers involved and the Cell Identification (Cell ID) of the site on which the call began and, in some cases, ended. The Cell ID is a number which can be referenced to a unique cell site within a particular mobile phone network of a specific country. Only calls which connect are usually shown on these records - this means calls and texts which are answered, either by a person or an answering machine/voicemail service. The details vary between networks, but it is usual that only calls which have been connected for longer than a set period of time (typically over 1 s) are included in the record and some networks may show details of both ends of a given call.

1.2. Mobile phone networks

UK mobile phone network operators have thousands of sites. Each cell site will consist of a mobile phone transmitter/receiver station and will provide radio coverage over a local geographic area. Network Operators will often locate these stations on masts, towers or other buildings. The Cell ID is transmitted by the station and the cell associated with
it is the geographic area in which this signal is dominant (otherwise known as the service area). A cell site is the physical location of the station or mast.

In a perfectly flat world, with equally spaced identical masts, a mobile phone user would generally connect via the closest mast. In the real world, however, this is not necessarily the case (Fig. 1).

A single cell site (usually a mast or building) can contain the hardware for several cells, which are then also known as sectors. Typically, there will be three sectors per cell site and each sector will usually point in a different direction (known as the azimuth) but this can vary, usually between one and six. The sectors will operate independently of each other, having unique Cell IDs usually related to each other and similar to the code for the covering cell site. Each sector will provide service over a particular geographical area, and this area will not be uniform (i.e., it will not be a circle, a triangle or any other regular shape); there may be many different shapes according to geography and the needs of the network (e.g., long, thin cells on motorways). It is also possible for temporary Cell Sites to be set up for specific events (e.g., festivals) or to be permanently installed but mobile (e.g., in a ship) (Fig. 2). There may also be disconnected areas of service known as ‘hotspots’ (a term which is also used by network operators to denote localised areas of phone usage). The terms ‘service/coverage islands also apply.

The service area of a given cell is dependant on many factors including the height of the antenna (aerial), the power used, the location of other cells and the geography of the land (hills, trees, etc) including surrounding buildings.

The range of a normally operating cell can vary from around 50 m up to maximum of 35 km from the mast (the theoretical maximum range for GSM, outside which a handset cannot transfer information with the mast no matter how powerful or well situated). However, with the factors noted above, the actual practical range is usually less than 20 km in rural areas, less than 5 km in urban locations and less than 2 km in city centre environments. Some cells, for example those indoors such as those installed inside shopping centres, can have much smaller service areas of a hundred metres or so and it is also now possible to have tiny cells providing service only within the confines of a home.

Users who are moving need to have uninterrupted service throughout an area so as not to drop a call in progress. To achieve this, networks try to ensure that cells overlap each other.

1.3. Selection of a serving cell

When a mobile phone is not in a call, it is in ‘idle’ mode. Despite the implication of the term, a handset in idle mode is still performing many tasks. The handset will constantly scan the network to determine which cell to camp on (‘camp’ means ‘select as server’). In order to determine the best serving cell to make/receive a call the handset continually monitors a number of cells and constantly selects the best one based on a number of factors including the signal strength (Rx level). Whether a call could connect at all in areas with poor coverage can potentially also be affected by other factors such as the power class of the phone used.

If a handset is directly in front of, and with line of sight to, the antenna for a given cell and with no other cells of greater or equivalent power close by, it would be unlikely to select any other cell. This means that within the service area of a given cell, there will be regions where a phone could not be reasonably expected to initiate (or respond to) a call on any other cell. The location in question could be termed as being within the ‘dominant’ region of the cell. The ‘dominant’ areas of a cell in an urban environment will usually be very small in comparison with the total area over which the cell is able to provide service.

Elsewhere, the received signal strength of other cells will be closer to or supersede that of the cell in question. The effects of clutter (either by line of sight or the effects of localised interference, or ‘fast fading’) will mean that there may be marked differences of signal strength over very small distances. If there are other cells serving the area with similar signal strengths, the cell selected as serving by the handset may change frequently. This (usually much larger) region is termed a ‘non-dominant’ area.

A new cell will generally be selected if the received signal strength of that which it is camped on is less than that of another measured handover candidate for a specific period of time, so the cell selected at any point in time will be affected by the previously selected cell. Two phones at the same location could therefore camp on different cells, even if they have similar received signal strengths of the cells serving at that location. If there is significant movement, the cell selected at a specific point can also be affected by the direction travelled as a cell is ‘dragged’ until its signal is significantly less than the alternative cells being monitored there. Clearly, any alternative cell would also be ‘dragged’ if travelling in the other direction.

Some cells may have a timing and/or signal strength offset applied to them; they must be monitored as having a higher signal strength for a period of time to be selected; this ‘hysteresis’ is by design to prevent ‘ping-ponging’ of calls between two cells (i.e., multiple handovers backwards and forwards between multiple cells). The amount of time spent at a location can also therefore affect whether a given cell is selected.

When a cell is in progress, the handset is in ‘dedicated’ mode. While also transmitting and receiving call data (and assessing call quality, something it is unable to do in idle mode) it will continue to monitor other cells to determine if there may be one more appropriate to carry the call. This information is reported back to the network, which then

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2 ‘Normally operating cell’. At the cost of capacity, it is possible to configure a cell for ‘extended range’. This configuration is rare, and if used at all would usually be limited to deployment on coastlines.
makes the decision in conjunction with other information as to whether the call should continue on a different cell (or ‘handover’ to it). A number of factors unknown to the handset can affect this e.g. criteria set to trigger the handover. Therefore, when in call the Serving cell is not solely selected by the handset as would be the case in ‘idle mode’.

1.4. Other factors affecting cell selection

When inside a building there may be additional complications in trying to assess those cells able to provide service. Network planners use guideline figures indicating a signal strength drop of approximately between 1/4 and 1/50 when entering a building, potentially increasing (if the building is large enough) to no signal strength at all.3 This drop off will not instantly take place as the building is entered, but the signal will attenuate as the user moves further and further inside and away from openings to the outside world (e.g. windows and doors). The rate of attenuation will vary with the type of material between the handset and the cell, and this may vary between different cells due to their different locations. This may result in different cells being selected at the front to those at the back of a property, for example, as the handset may have line of sight with one cell while the signal from an alternative cell is attenuated by the building. Likewise, the service area of a cell covering a deciduous forest may change with the season, as leaves can also attenuate signals.

There are further factors which may affect the cell selected by a handset such as when a network becomes congested. This may be encountered if there is a specific event which stimulates customers to make a call when normally there would be much lower rates of traffic (for example during sports events), when customers that normally have service at a location find they are unable to make a call or send a text.

In order to reduce congestion on a single cell, a function called ‘directed retry’ is available to network operators to use if they wish. This function enables the phone, if it is unable to set up a call on its currently selected cell, to select another cell on which to set up that call. The cell being selected as an alternative must also provide coverage in that location of sufficient strength relative to other cells in the area for the handset to monitor, but will not necessarily be the strongest cell detected there. The CDR may highlight the alternately selected cell as the ‘Starting Cell ID’ for that call.

Another function to make connection more efficient is the use of a BA List (Broadcast control channel Allocation List). This is a list of cells that a handset will monitor for possible handover and is transmitted by the cell on which it is currently camped. The handset will then ignore any cell which is not on the list no matter how strong its signal.

The BA List can contain information for up to 32 cells and is allocated by the operator. At a given location, however, not all cells able to provide service there will necessarily be on each others lists, and so it is quite possible that a handset camped on one cell will not monitor other cells able to provide service at that location.

2. Historic cell site analysis

Call Data Records will indicate the first (and sometimes last) cell which a mobile phone connected to at the time and date of a given call or text; an example is given below. The next stage of cell site analysis is to assess the area over which the cell could be expected to provide service and whether or not this includes specific locations of interest to the investigation.

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3. Assessing service areas

In order to determine if a call could have been made from a certain area there are a number of factors which need to be considered. If it is only necessary to assess whether a phone may have been in a specific town or region of a country then a desktop exercise can be carried out, taking into account details of the site (antenna point direction, height etc. if made available by the network e.g. via a legal request), wider network layout and physical geography. This type of exercise may also be sufficient if general movements of the phone are required, especially if the quantity of calls and distances involved are significant. However, if a more precise assessment is required, there are further options:

3.1. Best Server Prediction Plots (BSPs)

Best Server Prediction Plots (BSPs) can be generated by Network Operators to give a theoretical calculation of the likely area over which a given cell will provide service. It will usually take into account terrain, the height/power/direction of the antenna and the other cells providing service in the area. The service areas of different cells in a given area will not overlap as they do in real life, a calculation will be made as to which cell has a higher theoretical signal strength at a given point and therefore which is more likely to provide service. Thus the Plots give an idealised view of service areas that do not take into account factors such as effects of clutter, and will usually be underestimates of areas in which it is reasonable to expect a phone could have been when making or receiving a call on the cell in question. Plots can be used as indicators for such exercises, but may be flawed as they are not usually based on 'real world' measurements.

There are times when a BSP can be of great use. It is often quite difficult to obtain information from a network as to expected changes of service areas with time. A BSP from the time of the call in the CDR, overlaid with a BSP from the time of a later survey, can indicate whether the Network Operator is aware of any changes in the cells service area that could invalidate the survey readings.

3.2. RF measurements (surveys)

In order to assess which cells actually provide service at a specific location measurements can be taken. There are a number of ways in which the survey can be conducted. There is a range of terminology used in this area, below are definitions used by the Forensic Science Service®, UK.

3.2.1. Spot sample

A single or small number of measurements indicating a serving cell and other cells being monitored for handover at a specific point and time (e.g. front door of a specific address at a specific time). GPS may be used to indicate position, or the location may be manually noted.

3.2.2. Location survey

A number of measurements indicating the serving cell(s) and other cells being monitored for handover at
a specific point over a period of time (e.g. front door of a specific address for 5 min). GPS may or may not be used to indicate position as above.

3.2.3. Area survey
A larger number of measurements (usually hundreds or thousands) over a wider area that can be targeted around locations of interest. Data recorded will indicate the serving cell and other cells being monitored for possible handover along with the GPS location at which they are taken.

3.2.4. Cell survey
A very large number of measurements (typically thousands or tens of thousands) indicating where a specific cell provides service or is considered as a handover candidate along with the GPS location at which each measurement is taken.

3.3. The data can also be gathered in a number of ways

3.3.1. Drive survey
Vehicle based equipment with externally mounted antenna is used for data gathering. Drive surveys are only conducted on public roads, the data is rarely homogeneous and the drive strategy will generally be tailored to the question at hand.

3.3.2. Walk survey
If there is an area where a vehicle cannot access, man-portable equipment can be used. If outdoors, the measurements may be recorded against GPS locations. If indoors (and therefore outside GPS coverage) an electronic map may be used in conjunction with the equipment to indicate the route taken and co-ordinates automatically generated by the system.

4. Interpreting survey data

When analysing survey data a number of factors need to be considered depending on the case circumstances. Due to the inherent variability affecting the cell selected as server by a handset at a given point, consideration of the survey data is required. There are a number of ways of technically assessing the data:

4.1. Reporting serving and neighbour cells

From the measurements it is possible to report the serving cell measured at a specific location. However, in non-dominant areas this might not be the only cell capable of serving that location, so care needs to be taken in ensuring survey information is of sufficient quantity and quality for the result to be meaningful. There may also be other (quite specific) circumstances in which a call may be initiated on a cell which would not normally be selected in idle mode (for example if a phone ends a call on a traffic channel and then initiates a new call very shortly afterwards).

As part of the measurements, neighbouring cells (those cells being measured as handover candidates) may also be routinely recorded. In areas of non-dominance, or when attempting to predict in-building coverage, neighbour data can be useful to ensure that a given cell is not ‘falsely excluded’ from being considered as a possible server. It is, after all, being monitored as a potentially serving cell, and it may be possible under different circumstances that it could act as server. With the inherent variability of the sampling process outlined within this document, neighbour data is still usually of relevance but should not be used as a primary indicator of service as there may also be circumstances in which it is not reasonable to expect that a neighbour cell could provide service at a given location (e.g. overpowering dominance of another cell).

The ‘last Cell ID’ provided in the CDR will not have been selected purely by the handset, and so idle mode measurements will not be as useful in assessing whether a phone may, or may not, have been in a given location when the call finished. The selection of cells will, however, still be based on the neighbour measurements provided by the handset. With the assumption that the BA List is the same in dedicated mode as that in idle, the area over which the cell in question was measured as a handover candidate can indicate where the phone may have been at the time the call ended. This will be a much larger area than that where it would be selected as a serving cell.

4.2. Derived service areas

From drive survey results, and in conjunction with other data (e.g. topography), a map can be generated illustrating the region within which it is reasonable to expect that
a phone would be when making or receiving calls/texts via a specific cell.

A typical output is as follows:

The blue outline (in the web version) is the ‘derived service area’. It is the region within which the queried cell was observed as amongst those providing service, and is ‘inclusive’; it contains all those locations where the cell of interest had, at any point in the survey, been selected to provide service even if there were also other cells also seen to provide service there (shown as the red dots in Fig. 3, in the web version). Points at which it did not provide service, but was considered as a handover candidate (the yellow dots in the diagram, in the web version) can also inform opinion. Clearly there may be other cells that could be connected to from within the area and it is also possible, although less likely, that calls made from outside the defined area could also connect to it. This type of output, while based on large quantities of data, is still subjective (and therefore opinion-based) as the expert needs to consider all the variables outlined in this paper while defining the area including survey data, terrain, clutter and cellsite information (location, height, point direction etc.).

4.3. Experiment to assess reliability of survey methods

A number of experiments have been undertaken to assess the accuracy, repeatability and efficiency of the different survey methods outlined above. A typical scenario was used to enable this comparison:

"Which cells are able to provide service within a specific outdoor Car Park?"

The car park in question is in the centre of Birmingham, approximately 25 m square and, while open (i.e. ground level, open air, with 2 m high surrounding walls), has a number of 6 storey buildings within 100 m of it. The location has good coverage for all UK 2G and 3G mobile networks. For this exercise, only one of the UK 2G networks was surveyed (Fig. 4).

A number of positions were selected within the car park. Position 1 is located next to one of the walls and is approximately 40 m from the closest 6 storey building. Position 2 is in the centre of the car park and approximately 35 m from that building (Figs. 5 and 6).
Survey data was acquired using three types of equipment over a number of consecutive days. The equipment was:

- a) Crownhill Netmonitor System; 4 Independent systems or ‘boxes’ running on the same network (Specialist equipment).
- b) TEMS Survey equipment attached to a Sony Ericsson® T610 phone (Industrial Telecommunication Surveying equipment).
- c) Engineering Handset.

4.3.1. Experiment 1 – effect of small changes in location on survey data

Data was gathered in Position 1 and then Position 2 (~5 m apart) for 5 min.

4.3.2. Experiment 2 – effect of sampling period on survey data

Data was gathered by multiple pieces of equipment at each of the positions for 1 h without movement.

4.3.3. Experiment 3 – comparison of sampling method (spot sample vs. location sample vs. area sample)

The Crownhill equipment was used to carry out a Spot and 1 h Location Samples at Locations 1 and 2. An additional Area Survey of 300 m radius from the car park was carried out. The results generated by each of the 4 Crownhill boxes were then cross compared. The results of these measurements can be seen in Table 1.

4.4. Summary of results

The results presented in this paper are from the Crownhill equipment for ease of cross comparison, although the general patterns shown were found to be repeated with whichever sampling equipment was used (i.e. with TEMS or the engineering handset), so are believed to be indicative of ‘real world’ rather than equipment specific effects. ‘Valid’ Cell IDs are those cells that were detected as serving by any piece of equipment at any time within the Car Park. The results are illustrated in Table 1 at the end of this paper.

Consistency of results between multiple pieces of identical equipment was assessed.

Experiment 1 indicates that the Cell IDs monitored by a static sampling device can vary over time, as well as between similar devices in the same location at the same time. Significant differences in output can occur with small changes in position (~5 m). When the data was amalgamated to illustrate all Cell IDs detected in either location, no individual piece of equipment was found to have monitored all ‘legitimate’ Cell IDs either as serving or neighbour.

Experiment 2 indicates that lengthening a static sampling period to an hour does not necessarily generate more consistent or accurate data, as there was almost as much variation between the output of each of the boxes as with shorter 5 min samples.

Experiment 3 showed that no two pieces of equipment generated identical results no matter which method was used (spot, location or area survey). The most consistent and accurate method was the area survey, in which all four boxes detected all Cell IDs detected at position 1 or 2, although there were more Cell IDs detected as serving or neighbour using this method.

5. Advantages and disadvantages of survey methods

5.1. Spot samples

Advantages. Speed; obtaining the survey data and its subsequent analysis is much quicker than the other methods. ‘Quick confirmations’ may be possible if there is a specific hypothesis (e.g. there is a Cell ID from a CDR and a known location to check against) or the cell in question is clearly dominant at the location surveyed.

Disadvantages. Spot Samples showed great variability in results between pieces of equipment at the same location and with the same piece of equipment with small changes of position. There were many ‘false exclusions’ of ‘valid’ Cell IDs, so the absence of a Cell ID from survey data cannot be reliably used to indicate service could not be provided by a cell at a specific location or immediate area. The use of neighbour data did not enable all ‘valid’ Cell IDs to be assessed by any piece of equipment, and included Cell IDs that were also not observed to provide service there at any time.

These results emphasise the evidential issues associated with the effects of non-dominance or BA Lists described earlier in this document. Not only were some ‘valid’ cells not monitored but conversely use of neighbour data implies that some of the listed cells may be able to initiate a call when, in reality, they would be extremely unlikely to.

If measurements are taken at an early stage of an investigation, and further work requiring more surveying is subsequently required, it is also difficult to measure whether there have been changes (either by altered geography – e.g. construction or removal of buildings) or by network changes (addition or removal of cellsites). As no cell ‘boundaries’ will have been measured, the service area of whole cells may have shifted without it being apparent.

5.2. Location samples

Advantages: A 5 min location sample would enable cells with a timing offset to be selected. It is also a quick and efficient method for data collection and analysis.

Disadvantages: Location samples of 5 min duration showed a similar level of variability as spot samples. One hour Location samples continued to show significant variability in results with small changes of position and between pieces of equipment, but to a slightly lesser degree than the 5 min samples. Even with large amounts of data from a single location it is still less likely other cells will be reselected than with movement for the reasons given above. At both sampling positions no piece of equipment monitored all Valid Cell IDs as serving, and many neighbour cells were detected that never provided service. The sample
Table 1
Summary of results.

<table>
<thead>
<tr>
<th>Cell ID</th>
<th>Location Sample multiple readings from single location</th>
<th>Spot Sample single reading from single location</th>
<th>Area Survey 300m radius</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Position 1</td>
<td>Position 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>T1 (5 minutes)</td>
<td>T2 (5 minutes)</td>
<td>All data (1 hour)</td>
</tr>
<tr>
<td>1089</td>
<td>n</td>
<td>n</td>
<td>✓</td>
</tr>
<tr>
<td>8be1</td>
<td>n</td>
<td>X</td>
<td>✓</td>
</tr>
<tr>
<td>8be3</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>d236</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>ec53</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>ec55</td>
<td>n</td>
<td>n</td>
<td>n</td>
</tr>
</tbody>
</table>

| 1081    | n           | n           | X           | X           | n           | X           | n           | X         | n           | X           | n           | X           | n           | X         | n           | X           | n           | X           | n           | ✓         | ✓           | ✓           |
| 1082    | X           | X           | X           | X           | X           | X           | x           | X         | X           | X           | X           | X           | X           | X         | X           | X           | X           | X           | X           | X         | X           | ✓           |
| 1088    | X           | X           | X           | X           | X           | X           | X           | X         | X           | X           | X           | X           | X           | X         | X           | X           | X           | X           | X           | X         | X           | ✓           |
| 1090    | n           | n           | n           | n           | n           | n           | n           | n         | X           | X           | X           | X           | X           | X         | X           | X           | X           | X           | X           | X         | X           | ✓           |
| 1091    | X           | X           | X           | X           | X           | X           | X           | X         | X           | X           | X           | X           | X           | X         | X           | X           | X           | X           | X           | X         | X           | ✓           |
| a4d9    | n           | X           | X           | X           | n           | X           | X           | X         | X           | X           | X           | X           | X           | X         | X           | X           | X           | X           | X           | X         | X           | ✓           |
| c11c    | n           | n           | n           | n           | n           | n           | n           | n         | X           | X           | X           | X           | X           | X         | X           | X           | X           | X           | X           | X         | X           | ✓           |
| c11d    | X           | X           | X           | X           | X           | X           | X           | X         | X           | X           | X           | X           | X           | X         | X           | X           | X           | X           | X           | X         | X           | ✓           |
| c158    | n           | X           | n           | n           | X           | n           | n           | X         | x           | X           | X           | X           | X           | X         | X           | X           | X           | X           | X           | X         | X           | ✓           |
| c182    | n           | X           | X           | X           | n           | X           | X           | X         | X           | X           | X           | X           | X           | X         | X           | X           | X           | X           | X           | X         | X           | ✓           |
| d235    | n           | n           | n           | n           | n           | n           | n           | n         | X           | X           | X           | X           | X           | X         | X           | X           | X           | X           | X           | X         | X           | ✓           |
| ec54    | n           | n           | n           | n           | n           | n           | n           | n         | n           | n           | n           | n           | X           | X         | X           | X           | X           | X           | X           | X         | X           | ✓           |
| ec59    | X           | X           | X           | X           | X           | X           | X           | X         | X           | X           | X           | X           | X           | X         | X           | X           | X           | X           | X           | X         | X           | ✓           |
| ec9a    | n           | X           | X           | X           | n           | X           | X           | X         | X           | X           | X           | X           | X           | X         | X           | X           | X           | X           | X           | X         | X           | ✓           |
| 1063    | X           | X           | X           | X           | X           | X           | X           | X         | X           | X           | X           | X           | X           | X         | X           | X           | X           | X           | X           | X         | X           | ✓           |
| 1086    | X           | X           | X           | X           | X           | X           | X           | X         | X           | X           | X           | X           | X           | X         | X           | X           | X           | X           | X           | X         | X           | ✓           |
| d237    | X           | X           | X           | X           | X           | X           | X           | X         | X           | X           | X           | X           | X           | X         | X           | X           | X           | X           | X           | X         | X           | ✓           |

Key:
- Cell IDs detected, at some point, by static surveys in location of interest
- Cell ID Detected as providing service
- n Cell ID detected as neighbour (handover candidate)
- X Cell ID not measured in any capacity

B1 Box 1
B2 Box 2
B3 Box 3
B4 Box 4
limitations that apply to spot samples also need to be considered when using a location sample.

5.3. Area surveys

Area surveys had the least variability in results between pieces of equipment. Not all valid Cell IDs were detected as serving on all boxes (one Cell ID detected in the car park was detected as a neighbour but not as serving by two of the four boxes). The Cell ID in question had also been the least reliably monitored during the static sample tests (detected by two boxes in position 2 for the 1 h test and not by any box in the 5 min tests at either position).

With neighbour data taken into consideration (which would be of use if there was a subsequent, specific, hypothesis concerning that Cell ID proposed), there were no false exclusions of legitimate Cell IDs from any piece of equipment using this method. The absence of a Cell ID from survey data (including neighbour data) could potentially be used to exclude possible service by that cell at the location sampled.

Advantages: Optimisation of the chance of cell reselection, minimising the effects of restricted BA Lists and non-dominance. While not infallible, there is a much clearer indication of which cells genuinely provide service at and in the immediate area of a location or property.

Area surveys provide a wider picture of the general network configuration around the area of the location, enabling comment as to possible network changes if further work is required at a later date.

Disadvantages: it takes longer to generate data, more data is generated and is more complicated to analyse, adding time to the examination (and therefore cost). It also does not routinely obtain large quantities of measurements at a single specific location (although nothing precludes staying at a given location to do this) for cells with a timing offset to be selected.

More possible cells will be identified (some may be ‘false positives’ for that specific location, especially if they are ‘small’ cells at the edge of the sampled area); this was estimated as an increase of ∼20% by the experiments conducted. Of course, these cells may become relevant to an investigation as they are detected in the local area even if not at the specific location selected as target. It is rare that a specific point is highlighted as being where a call was believed to have been made from.

5.4. Cell surveys

The advantage of this type of survey is that the size of the area served by the cell can be demonstrated. This can be extremely useful in either highlighting the limitations of the cell site evidence (if the cell provides service over a large, and relevant, area) or emphasising its importance (e.g. if the service area is very small).

6. Conclusion

There are a range of factors which impact on the cell which a handset will select at a given location and therefore appear in the Call Data Record generated by a call at a specific location. A number of survey techniques have been reviewed to determine the most reliable method for collecting RF survey data for Historic Cell Site cases. Results from experiments have demonstrated that Area Surveys around a location of interest (within 300 m for this experiment) provide the most accurate and consistent method for detecting serving Cells at a location. Area Surveys were also more reliable for excluding Cell IDs from a location, and for assessing possible network changes if further surveys take place at a later date.

Further reading/resources
