

# Problems with cell phone evidence tendered to ‘prove’ the location of a person at a point in time

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## Introduction<sup>1</sup>

Some years ago, through our participation in a post conviction inquiry into a murder case in which the investigators and lawyers misinterpreted mobile telephone records,<sup>2</sup> we became concerned about the inaccurate use of mobile telephone records to place the whereabouts of a telephone (and its user) as evidence in criminal trials.<sup>3</sup> In the years since matters have not improved. However, in 2015 the Commonwealth Government enacted new requirements<sup>4</sup> for the Australian Telecommunication companies (Telcos) to keep data. With respect to mobile telephone records it is useful to note that:

- (i) there are over half a million requests per year for meta data (ACMA 2012/13);
- (ii) the Telcos keep call charge records (CCRs) for more than two years, but there were commercial pressures to reduce this time to weeks in the case of IP addresses;
- (iii) there has been no legal clarity as to who can obtain access to these CCRs; and,
- (iv) there has been no standardised format for the content of CCRs. For example, the Telcos’ algorithms for deriving a CCR and thereafter a client bill have been variable, so that some CCRs have not shown the initiating ‘ID’ of a transmission tower.

<sup>1</sup> We acknowledge the assistance and input from Dr Ted Buot, an experienced ex Nokia Cellular Planning Engineer and PhD student of Professor Coutts in the 1990s. We draw the attention of the reader to the following useful references: Thomas A. O’Malley, ‘Using Historical Cell Site Analysis in Criminal Trials’, in US special issue on Obtaining and Admitting Electronic Evidence (Attorney’s Bulletin, November 2011, vol 59, #6, Special Issue), 16 – 34, available at

<https://www.justice.gov/sites/default/files/usao/legacy/2011/11/30/usab5906.pdf>; Aaron Blank, *The Limitations and Admissibility of Using Historical Cellular Site Data to Track the Location of a Cellular Phone*, XVIII RICH. J.L. & TECH. 3 (2011); Judge Herbert B. Dixon Jr., ‘Scientific Fact or Junk Science? Tracking a Cell Phone without GPS’, *Judges’ Journal*, Volume 53, Number 1, Winter 2014, 37 – 39; Michael Cherry, Edward J. Imwinkelried, Manfred Schenk, Aaron Romano, Naomi Fetterman, Nicole Hardin and Arnie Beckman, ‘Cell Tower Junk Science’, 95 *Judicature* (2011-2012), 151 – 152.

<sup>2</sup> The case of *Phuong Canh Ngo*, see *R v Ngo* [2001] NSWSC 1021 (the sentence); *R v Ngo* [2003] NSWCCA 82 (appeal); David Patten (Judicial Officer Conducting Inquiry), *Report to the Chief Justice of New South Wales (The Hon J J Spigelman AC) of the Inquiry into the Conviction of Phuong Canh Ngo for the murder of John Newman* (14 April 2009), available at

[http://www.lawlink.nsw.gov.au/practice\\_notes/nswsc\\_pc.nsf/6a64691105a54031ca256880000c25d7/f1ef2541db38ae82ca25759b00052606/\\$FILE/Report\\_Phuong\\_Ngo\\_140409.pdf](http://www.lawlink.nsw.gov.au/practice_notes/nswsc_pc.nsf/6a64691105a54031ca256880000c25d7/f1ef2541db38ae82ca25759b00052606/$FILE/Report_Phuong_Ngo_140409.pdf); *Phuong Canh Ngo – Application under Part 7 Crimes (Appeal and Review) Act 2001* [2010] NSWSC 981 (decision on the papers following a new application for review after Patten Report published).

<sup>3</sup> Based on that experience, Coutts and Selby presented a paper ‘The Safe and Unsafe Use of Mobile Phone Evidence’, at the Communications Policy Research Forum (CPRF2008) September 29-30th, Sydney 2008, and later at the NSW Public Defenders’ Conference, ‘The Safe and Unsafe Use of Mobile Phone Evidence’, Public Defenders Conference, January, Sydney 2009. This article significantly updates the 2009 talk.

<sup>4</sup> Telecommunications (Interception and Access) Amendment (Data Retention) Act, No 39/2015, which amended the Telecommunications (Interception and Access) Act 1979.

Under the recent legislation in Australia, the Telcos must keep standardised data for at least two years (see section 187C). That standardised data set includes, among other things, the following (see section 187AA): subscriber; billing or payment information; source and destination of communication; date, time and duration of calls; type of communication (e.g. voice, SMS, email, chat, etc); type of service (e.g. ADSL, VoIP, cable, etc); and the location of equipment (e.g. a cell tower, Wi-Fi hotspots, etc.) at the start of the communication.

From both prosecution and defence perspectives these changes may or may not occasion less misuse of ‘communication data’ in those cases that post date the introduction of the ‘new’ standards. However, those cases for which the relevant records predate the new legislative requirements will be adversely affected by the earlier vagaries and limitations of the stored data.

## The basic information about mobile communications

It is our experience that investigators and lawyers do not understand the mobile telephone ‘data’ with which they deal. Hence the following information is

intended to make the discussion in the rest of this paper more easily understood.

### General

Public mobile telecommunications networks, of which there are three in Australia (Telstra, Optus and Vodafone), are extensions of the main fixed network that is often referred to as the public switched telephone network (PSTN). The mobile networks are connected to the PSTN at points of interconnect (POIs), allowing mobile users to dial any other users based on an international numbering system.

### Mobile network

Each mobile network consists of a large number of service areas of coverage (e.g. a city or town) that are interconnected to the PSTN at the proximate POIs.

A mobile user has a ‘home location’ (e.g. a city) and their subscription information is kept in a database known as the Home Location Register (HLR). When the user takes their mobile to another location (e.g. another city) and switches it on, then their subscription information is relayed to and kept at the corresponding Visiting Location Register (VLR) so that if a call is made to the ‘roaming’ mobile user, the call will be immediately routed to the VLR.

A large service area (e.g. a city) is split into a number of location areas. Each location area contains a number of base stations that provide near continuous radio coverage. The association of base stations with a particular location area is stored in the Mobile Switching Centre (MSC) (one or two per city) which is in turn connected to all the base stations using a variety of transmission facilities called Backhaul Links.

### A mobile originating call

When a mobile user dials the number of another user in the global network, the mobile establishes a Signalling Channel to relay the number dialled to the MSC which (assuming the user is valid) analyses the number and sends a ‘ring tone’ to the dialled user via the PSTN. If it is a mobile to mobile call, the MSC at the ‘receiving’ end pages (sic) the mobile in the identified location area. It is only if the dialled user ‘picks up’ the call that the MSC then directs the set up of a Traffic Channel, usually to the ‘best server’ base station to the originating mobile user. Hence, it is only when a connection is established that a Call Charge Record (CCR) is established, noting the Cell ID of the base station that was used to carry the start of the call. It follows that if a mobile user attempts a call that

is not ‘picked up’ by the end user (the term ‘pick up’ includes an answering service) then no CCR is generally created.<sup>5</sup>

### A mobile terminating call

When a user in the global network calls a mobile user (as distinct from calling a fixed telephone on the PSTN), a signalling message is sent to the relevant MSC and HLR associated with the mobile number being called. In the case of a ‘roaming’ mobile the message will go to the VLR. The MSC then pages (or ‘pings’) all the base stations within the location area associated in the HLR (or VLR) with the active roaming mobile (that is if the mobile is powered on and away from home.) The receiving mobile detects its unique mobile identifier from the page (‘ping’) indicating an attempted incoming call, and uses the signalling channel to ‘accept’ the call and establish a traffic channel as mentioned above. It is only then, when the receiving mobile call is accepted, that a CCR is generated. The CCR gives the Cell ID of the cell site used to establish the traffic channel marking the beginning of the call by each and both of the originating and terminating mobile telephones.

### Handover

When a mobile (be that initiating or receiving) is moving within a service area or with cell congestion, then the mobile can message to change over to a different base station to assure the continuity of the call. Only the cell ID at the point of the start of the connected call is retained in the CCR. Hence the CCR does not give any information about possible movement of either or both the initiating or receiving mobile during the currency of a call connection. No records are kept of such movements.

### Implications

Recourse to the CCR Cell ID is useful only to establish a possible area in which *a sending mobile was located* when a call was made from that mobile and ‘picked up’ by a receiving telephone. The possible area within which a mobile call was initiated can be further analysed and delimited by the use of software predictive coverage maps, combined with appropriate field testing.

Hopefully the above information will help the reader to readily grasp the following discussion. The price of

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<sup>5</sup> There are exceptions where a simple CCR can be generated.

not grasping those fundamentals is shown in the following example.

This is a report of a jury trial in NSW just a few years ago. The reporter was assigned to report on the advocacy seen and heard at that trial:<sup>6</sup>

A prosecution witness gave evidence about mobile phone call records and the cell towers involved in transmitting specific calls. The mobile phone in question was that of the accused, and the location discussed was around the scene of the crime.

### Examination in Chief

The examination in chief by the prosecution started out with too little information on what topic was going to be examined and where the questions were heading. The prosecutor was having difficulties in phrasing questions to the witness, with his questions often confusing the witness and the judge. On several occasions the judge had to re-phrase the question for the witness, and I could see that the judge was getting frustrated with the prosecutor for his lack of clarity in his questioning. The prosecutor then attempted to tender several voluminous documents to the court (which were lists of call records and maps of cell towers in a particular area of Sydney), however he had failed to make adequate copies for the jury.

The judge adjourned the hearing for a short break while the prosecution made enough photocopies for the jurors. The prosecutor was also having difficulty managing the witness, who looked and sounded surprisingly uncooperative, talking over the prosecutor on several occasions. The examination in chief as a whole felt confusing and tedious, and it was not entirely clear what exact point the prosecutor was trying to establish.

### Cross-examination

The defence advocate had a clearer style of questioning, and the witness was having much less difficulty in answering the questions. This made it much easier to follow the topic being pursued by the defence.

Towards the end of the cross-examination, there was an unexpected development. The defence cross-examiner asked what appeared to be a key question for the defence: whether or not a particular mobile phone call record put the accused in the vicinity of the location of the crime. The witness stated that he was not in a position to answer that question. This answer seemed to come as a surprise to the defence advocate, who then anxiously asked a few follow up questions to no avail.<sup>7</sup>

After the jury and the witness left the courtroom, a discussion took place between the judge and the advocates, and it became clear that the witness had apparently changed his position on this key issue since the last meeting he had with the defence advocate. The defence had based most or all of its case on this witness’s previous position that the phone record suggested the accused was likely not in the vicinity of the crime at the relevant time. Now that this witness had apparently changed his position, the defence advocate appeared to be nonplussed. The judge also sounded concerned, and suggested the issue be dealt with by way of *voir dire*<sup>8</sup> the next day.

Against the background set out above, we now consider some of the ever-present issues about mobile telephone use that confront experts and trial advocates.

## The experience and training required to offer opinions in this field of expertise

In our view, to be ‘qualified’ as an expert in this area requires the following:

- (i) A knowledge gained from experience of what information is available from the mobile

<sup>6</sup> This raises the interesting question as to why this witness was called by the Crown at all. Unfortunately we have no further information.

<sup>7</sup> Editor’s note: in jurisdictions such as Australia, England and Wales and New Zealand, a criminal trial takes place, with rare exceptions, before a judge and a jury of up to 12 persons. In short, the judge controls the case, decides on the law, decides whether witnesses are qualified and competent to give evidence, and decides whether evidence is to be given to the members of the jury. The members of the jury decide, on the evidence brought before them, whether the accused is guilty of the offence. If evidence is in dispute, or if there is an argument between the parties on a matter of law, the judge will hear the evidence or listen to the legal argument in the absence of the members of the jury. Where the evidence is in dispute, the Latin term ‘*voir dire*’ is used to indicate that a trial within a trial takes place.

<sup>6</sup> The reporter was a member of an advocacy training class conducted by co-author Selby. Such trials are not ‘reported’ unless there is a point of law determination or an appeal.

network operators (MNO’s), such as the Call Charge Records and other aspects of the evolving mobile technologies;

(ii) A knowledge and experience of the complexities of radio propagation around 1GHz;

(iii) A knowledge of radio coverage in the mobile environment such as clusters of cells, use of multiple carriers per site, interaction of various technologies (GSM/3G/LTE) and radio resource management; and,

(iv) A knowledge of the strengths and weaknesses of propagation prediction tools.

Some, but not all of this knowledge can be gained from tertiary training. The expertise is mainly acquired while working as a radio field-test engineer or radio optimiser dealing mainly with how cell coverage and traffic load are handled by various network technologies.

### **The technical information an expert would like to have when being asked for an opinion about where a telephone was likely to have been located when used at a critical time(s)**

Call Charge Records (CCRs) must be obtained from the mobile carrier. Current CCRs generated for all calls provide details of the base station and cell site for all originating and terminating calls. However, there is considerable variability among the Telcos, and even among different geographical regions of a single Telco.

For the layperson, the initial indicator of a mobile location is provided in the Billing Record, where for each billable call, the ‘call origin’ is provided. The call origin encompasses calls from a cluster of geographically related base stations situated within one area and is usually insufficient to provide satisfactory location details for legal purposes. (Please note that Billing Records are derived from CCRs and have much less information. The main purpose of a billing record is to resolve customer queries.)

Generally in urban service areas, each base station has three sectors (identified by their cell ID). Directional antennae illuminate these three distinct sectors. Each sector ideally covers a 120 distinct degree arc (thus the three sectors cover the whole 360 degrees);

however, a more reliable sector coverage can be gained by using several graphs of coverage from the operator’s software prediction software tool as follows:<sup>9</sup>

(i) One plots how far the signal *should go* with adequate signal strength; an example is shown in Figure 1 below.

(ii) The other takes into account all the surrounding cells and plots *the dominant cell coverage* in that area. The corresponding example is shown in Figure 2 below.

Such software tools are useful, but not determinative, for the expert in estimating the effect of the physical reality surrounding the directional antennae. In the absence of the ‘real’ field tested data about terrain, obstructions and foliage, an expert can only make a rough estimate based on idealised cell coverage. The expert also needs the engineering details of the base station and the antennae to substantiate any approximate estimate.

Such estimates of coverage are highly variable, and their interpretation for the purposes of evidence needs to be challenged more often than it has been to date. If there is a suggestion that a particular cell was not working or that it was bypassed (because it was too busy), then the expert may need to consider other records with respect to that particular cell site and the traffic conditions at the time of interest.

### **Possible Coverage (Adelaide Airport)**



Figure 1: An example of ‘possible coverage’ prediction

<sup>9</sup> This software tool uses the topographical data base and propagation formulae to plan coverage area.

## Probable Coverage (Adelaide Airport)



Figure 2: An example of ‘probable coverage’ prediction

Following the appropriate expert witness guidelines for any given jurisdiction (which the litigation lawyer must provide to an expert at the beginning of the engagement), the expert needs all available data. The necessary data are set out below.

(i) The CCRs: calls *from* mobiles are listed in the CCR *as if* they originated from the mobile of interest. While the detail varies between the three mobile network operators (MNOs) in Australia, they generally provide the following information:<sup>10</sup>

- (a) Commencement time and date of the call.
- (b) The duration of the call.
- (c) The cell ID used at the commencement of the call.
- (d) The number of the call termination.
- (e) Where the call is terminated by a mobile, the cell ID of the terminating mobile.
- (f) Other information (depending on the MNO) such as voice mail, location area of the cell, switching Centre Information and type of call (SMS, voice, data, diverted call, etc).
- (g) For the Telco ‘Vodafone’, it is necessary to ask for the CCRs of both the originating and terminating telephones.
- (h) The software prediction plots of propagation (described above) for the various towers through which the calls of interest may have passed. Note that:
  - (i) It takes several weeks for the Service Providers to provide this data. It follows that ‘last minute’ exercises

are impossible. Moreover, not all Telcos will provide this information.

(ii) Only in a recent case in late 2015 (see below) have the results (i.e. the maps and their implications) of such software been challenged in Australia.<sup>11</sup> Such maps can be highly prejudicial against the accused if they are not challenged.

(iii) Other data might be relevant in different cases: for example, the actual propagation characteristics of a base station antennae are required to examine the possibility of a call being received close to the back of the recorded cell ID. The ‘front to back’ performance of the antenna can be less than ideal. This aspect of software prediction modelling can be particularly poor.

## The instructions the expert needs from the lawyers

Because of the quantity of data available, the expert generally needs to know a range of additional information, such as: the day or days that are thought to be significant; the competing hypotheses of the parties, be the case civil or criminal; how much time is available to prepare the report, and whether adequate funds can be put in the Solicitor’s Trust Account to cover a preliminary assessment by the expert.

## The variability among Telcos

In one case, co-author Coutts was supplied by the client’s lawyers with a large bundle of Telstra bill records. Their instructions were to explain the meaning of ‘origin’ as shown in the Telstra records. Telstra uses ‘origin’ to denote a cluster of base stations covering a variable area. The ‘origin’ can, in some cases, be a sizeable area. In other cases, Coutts has been given ‘base station’ data that is a component of CCRs. For the Northern Territory and Western Australia, the base station information does not come

<sup>10</sup> In the Northern Territory, the Vodafone CCRs were more limited until 2012 because they gave the base station but *not* the sector (i.e. cell ID), thereby limiting their usefulness.

<sup>11</sup> The software prediction charts were finally admitted for consideration by the jury in the full trial, but only after ‘on site’ validation occurred during the course of the trial within a trial (voir dire) at which their probative value was contested.

with any information as to which cell of the base station was used. This is an example of one Telco recording different types of data in different geographical regions within Australia. The date when an incident occurred will influence what data is involved. There may be more or less data available.

In the case of a ‘data session’ (as distinct from a telephone call) the interpretation of the CCR is slightly different in that, as illustrated in Figure 3 below, the start time is several seconds after the start of the call, and the duration of the data session as illustrated in Figure 3 depends on the technology (e.g. 3G, GSM) and the variation of noise and interference during the call.

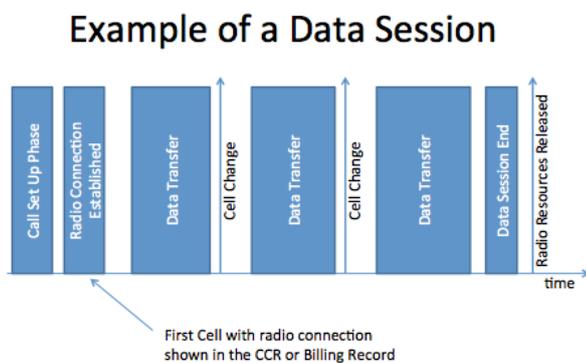


Figure 3: A data session

### Misuse of mobile telephone evidence and how such errors mislead fact finders

The use of mobile telephone evidence as a means of accurately locating the telephone and its user is problematic. Let us examine why this is so.

When an outgoing mobile telephone call is made, a CCR is created. Within that record is the identification of the originating and terminating cell(s) (it can be the one cell for both) from which the call originated or was received. This is called the Cell ID.

Mobile telephone networks use many towers to create network coverage. The transmission from each tower is usually by way of one of three sectors (as mentioned above) – imagine a pizza on top of the tower cut into three slices or sectors. The Cell ID identifies the sector of intended coverage. In the case of a three sector base station, each sector covers an angle of 120 degree emanating from the base station.

However, the ‘dominant’ area of coverage of the sector in practice is variable. The coverage will depend upon the network coverage design (i.e. the relationship with the surrounding coverage provided by the other base stations to assure continuous service) at the time of the call. To respond to different levels of the broadcast wattage (power), topography and demands of use, there is some ‘overlap’ of sectors, but not nearly so much now as with early systems.

Topography, the weather, the amount of use, the broadcast wattage, and overlap of cells that cover the area will affect connections. If a technician were to conduct a test by physically standing at a particular point (point ‘A’), the results of the test will only apply to the time and date that the test was made. The results of the test will not ‘prove’ that at some other earlier date and time, calls from point ‘A’ went through the specified sector identified in the test call. The call in question might have gone through another sector. When a user places a call, the cell phone connects to the cell site with the strongest signal. Factors that affect the strength of the signal include whether the telephone is inside a building, or out in the open, and the orientation of the telephone to the user’s head. These are important considerations when attempting to recreate an alleged past event.

In general it is often easier to be more definitive about the converse proposition, *namely that from the Cell ID information it is unlikely that the call was made (or received) outside a specified area.*

Access from the Telcos to propagation prediction modelling (i.e. for both ‘dominant’ and ‘possible’ coverage of relevant sectors) is helpful but insufficient to be certain about telephone location. In this context of qualified uncertainty, it is highly misleading to infer positive location with the phrase *‘the Cell ID identified with a call is consistent with the call being made in that location.’*

It is essential that lawyers, be they prosecutors or defence counsel, approach the use of CCRs and their component data by considering the strength of the evidence. Given that a person of interest is believed to have used a mobile telephone, thereby generating call charge records, the issue is to determine the strength of the evidence to establish whether the person was in or around a defined area, versus, the strength of

the evidence if the person of interest was in or around a different area.<sup>12</sup>

### The three types of signal (that is analogue, and the two types of digital)

Broadly there are three generations of mobile technology that need to be distinguished when determining location from Cell ID data. They are:

- (i) First Generation AMPS technology (analogue) from 1987 until closure in 2000. AMPS networks often had large cells of up to 50km in extent, and the sectors from the adjoining base stations significantly overlapped.
- (ii) Second Generation GSM technology from early 1993 with smaller cells (e.g. < 20km) and more complex ‘cell hand-over’ methods between adjoining base stations to minimise cell overlap. For GSM systems, cells are strictly limited to less than 35km due to the technology architecture.<sup>13</sup>
- (iii) Third Generation WCDMA technology that from the early 2000s co-existed with GSM. WCDMA has even smaller cells (e.g. < 2km). A typical network would use GSM and WCDMA to cover mixed rural and urban service areas.
- (iv) Fourth Generation (Long Term Evolution, or LTE), since around 2009. Like 3G, it uses small cells. It has a focus on data rather than voice calls; however, as its use for voice calls increases, there is a decline in the use of the 2G technology for voice calls. Note that fourth generation technology does not affect the discussion regarding cell size.

Three important points are that:

<sup>12</sup> For those not familiar with a ‘scientific approach’ to evaluative evidence, and in particular ‘likelihood ratios’, please refer to Charles Berger, Bernard Robertson and G.A. Vignaux, ‘Interpreting Scientific Evidence’ (chapter 28) in In Freckelton and High Selby, *Expert Evidence* (Thomson Reuters), online and looseleaf.

<sup>13</sup> The GSM mobile technology was the first ‘digital mobile technology’ introduced in Australia by the Telcos from 2003. GSM uses Time Division Multiple Access (TDMA) technology which uses time slots to multiplex the respective channels of information. To correctly extract the respective information at the reception point, all signals must be delayed in the correct time (termed time build out) depending on how far they are from the receiving base station. The maximum delay between a signal transmitted close to the base station and the outer edge of the base station is the distance it takes a radio signal (i.e. the speed of light) to travel 1 time slot, which for GSM corresponds to 35km. That means for GSM and only GSM the maximum distance is 35km.

(i) The rationale for placing towers has changed over the last 20 years, evolving from the first generation technology.

(ii) The second to fourth generations of technology can operate below 1GHz, thus providing greater propagation distance. Both GSM and WCDMA also operate at 2GHz that can support more load capacity in smaller cells. WCDMA (e.g. Telstra’s NextG™) uses a wide range of cell size depending on network requirements. Hence it would be wrong to assume ‘standard’ size sectors when offering opinions about the location of a telephone.

(iii) With GSM technology in particular, the system limits propagation to less than 35km. This limitation in one case (discussed below) has been used to refute claims of a witness as to his location at the time of a call.

### Software propagation tools: what they are; what data they require, and how their quality has developed

Software prediction tools predict the extent of ‘multipath’ radio propagation from a base station, based on system factors (including power, frequency band, antenna configuration), and topographical data (e.g. hills, trees, buildings, water) for a particular terrain. From the mid 1980s, when cellular mobile systems were introduced, software propagation tools have been used by the Telcos to plan coverage. Simplistic hexagon descriptions as used in the class room or court overly simplify the complexities of coverage. There are four important points to be aware of:

- (i) These tools are statistical in nature and are further limited by the modelling capability and quality of the ‘inbuilt’ topography.
- (ii) The network configuration changes over time to allow for expansion. Hence the current modelling data may not be that applicable to the time of the telephone call in question.
- (iii) Different software tools use ‘prediction models’ (e.g. Hata) and the correct input information (e.g. foliage description) should be tested by proper ‘field’ measurement to be used as evidence.

(iv) Such models do not account for anomalous propagation effects (e.g. the effect of weather and water reflections).

### Why mobile vans are used to check coverage

The actual measurement of the relationship between the location of a telephone and the cell site used would seem to be a useful thing to do, until one appreciates the scope of the problem (e.g. locations, movement, direction of the caller) aside from the random elements involved. A good illustration for the layman is the experience of observing that the base station name on the telephone changes as we move our mobile telephone about.

The measurements of actual telephone calls and associated cell IDs are *never* used (other than incorrectly in some courts) to confirm an inferred location. This is because such ‘confirmation’ would require many measurements, undertaken under a controlled situation, with consideration of various hypotheses to assess relative likelihood of each hypothesis. From the earliest days of cellular mobile systems, Telcos have deployed vans with measurement equipment to investigate the coverage of a particular area, or problems of interference that the software prediction tools do not and cannot predict. As these measurements generate huge amounts of data to be statistically representative, they are only carried out to validate modelling deficiencies and improve design. In late 2015, mobile vans were used to test ‘predictive coverage maps’ that the prosecution intended to rely upon in a Victorian jury trial with respect to a specific base station. See a discussion of this case below, under ‘another case of misuse of coverage maps’.

### Current technology comes closer to indicating a position for a mobile telephone than in the past because there are many more towers and much less overlap than in past years

As explained above, mobile technology has evolved through several generations to cope with the volume of mobile calls. Thus the AMPS mobile network to support a million customers in Sydney in 1994 has evolved into a hybrid GSM/WCDMA network in multiple frequency bands able to support 5 million people. This modern mobile network has smaller cells

in the city with minimal overlap compared to the earlier AMPS network.

When only the AMPS network was available, it had considerable overlap of cell coverage. In such circumstances, there was a significant possibility that the Cell ID shown on the CCR might not be the cell site closest to the physical site of the telephone making the call. With today’s technology, the Cell ID is more reliable than was possible with AMPS. Nevertheless, even today, inferring location from Cell ID with this finer cell structure is still fraught with potential errors of interpretation, just as it was in the 1990’s for AMPS.

It has been a practice (how common we do not know) to proffer as prosecution evidence that a telephone was in or around a location (supportive of the prosecution case) at a particular date and time on the basis that at some *later* date a number of calls are made in that location, and one or some of the calls use a cell that has coverage of that location. This practice has the following significant deficiencies: it has no scientific credence unless it includes comparable testing of other places at which the telephone may have been used (as the defence might claim) to ascertain if any such call uses the same cell; and, beyond the simple making of numerous test calls and recording how many succeed and how many fail, there is also a need to explain the basis on which it is claimed that such tests are a fair method of assessing the likelihood that the telephone was at the ‘desired’ location.

### Some examples of case requests to comment upon CCR based evidence<sup>14</sup>

**Misuse and misinterpretation of coverage maps**  
The CCRs of mobile calls combined with the coverage maps from the Telco (shown below) appeared to show that an accused could not have been where he said he was, but that he was at the scene of the crime. The defence experts were not given these CCRs and maps, or the Crown ‘expert’ witness’s statement as to the interpretation of this material, until the end of the Crown case.

Upon examining these coverage maps, it was clear that the strength of the Crown case was overstated. The experts were retained too late by the defence to

<sup>14</sup> The examples are drawn from actual cases for which co-author Coutts was commissioned to provide expert advice. They are not ‘reported’ cases.

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advise on the basis for objecting to the admissibility of the evidence (as was achieved in the following case, below).

To understand the following explanation, please refer, as indicated in the text, to the various maps below.

After viewing the CCRs and maps, a non-expert (such as an investigator, prosecutor, defence lawyer or juror) would conclude that the accused was lying when he claimed to being at home (i.e. at home on Canning Road), because *none* of the 25 calls used the Kalamunda South cell site (his ‘most probable’ coverage site – see Figure 2 below). However, the calls in question used two of the Lesmurdie South sectors. The Lesmurdie South sectors include the site of the crime (i.e. 112 Pickering Road) within their ‘most probable’ coverage prediction (maps 3 and 5).

After a closer examination of the propagation maps from the Telco, and by checking the ACMA site data base, the following additional information indicated: that the Lesmurdie South antennae were located on a broadcast tower and were therefore very high in the air (i.e. 60m compared to 14m for the Kalamunda site), and the ‘back-lobe’ propagating prediction for the Lesmurdie South antennae (maps 4 and 6 for the 2 sectors) raised significant suspicions as to the reliability of the software prediction tool. It is plausible that the accused’s home is within line of sight (LOS) of Lesmurdie, suggesting gross errors in the software predictions.

Here are the 6 maps:

Figure 1: Plot showing Prediction of Probable Cell Coverage Area for “Kalamunda-O:P0039-OU21-A-2” on 26/10/2013.

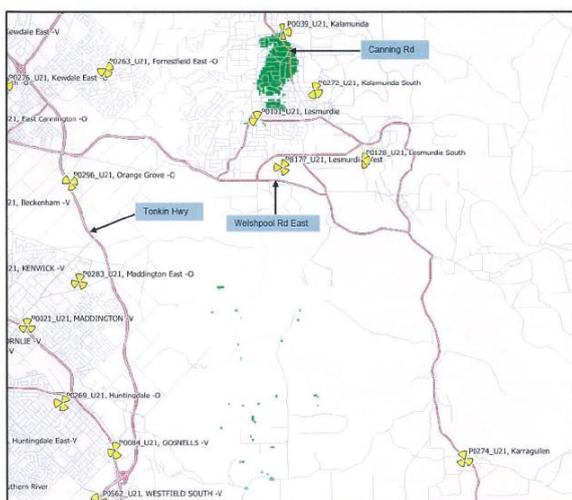


Figure 2: Plot showing Prediction of Possible Cell Coverage Area for “Kalamunda-O:P0039-OU21-A-2” on 26/10/2013.

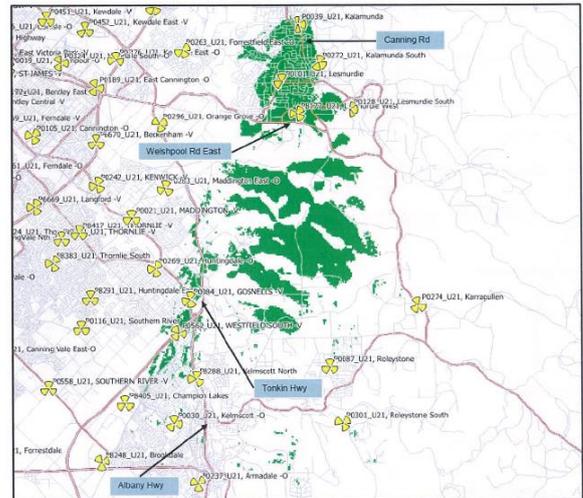


Figure 3: Plot showing Prediction of Probable Cell Coverage Area for “Lesmurdie South-O:P0128-OU21-A-3” on 26/10/2013.

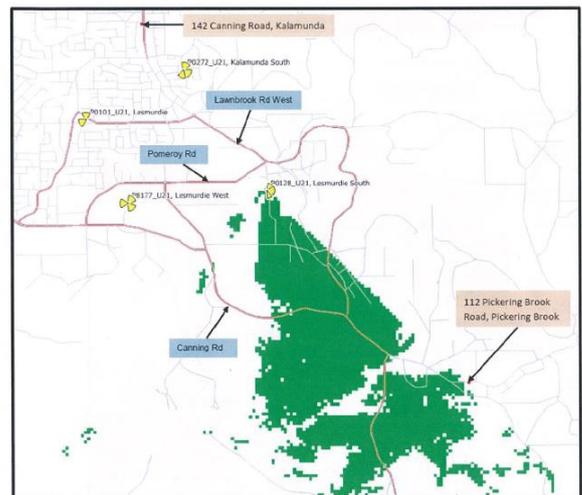


Figure 4: Plot showing Prediction of Possible Cell Coverage Area for “Lesmurdie South-O:P0128-OU21-A-3” on 26/10/2013.

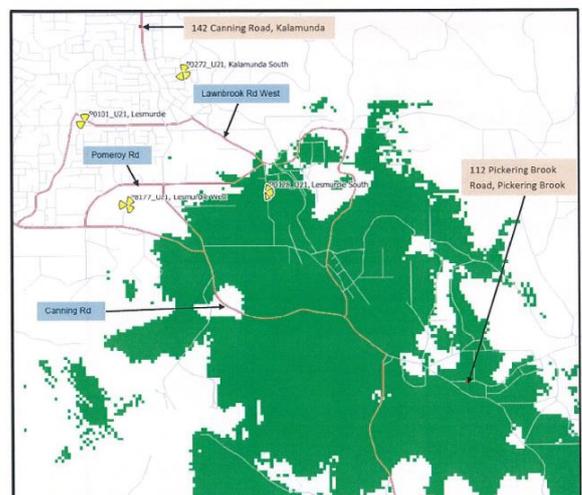


Figure 5: Plot showing Prediction of Probable Cell Coverage Area for “Lesmurdie South-O:P0128-OU21-A-2” on 26/10/2013.

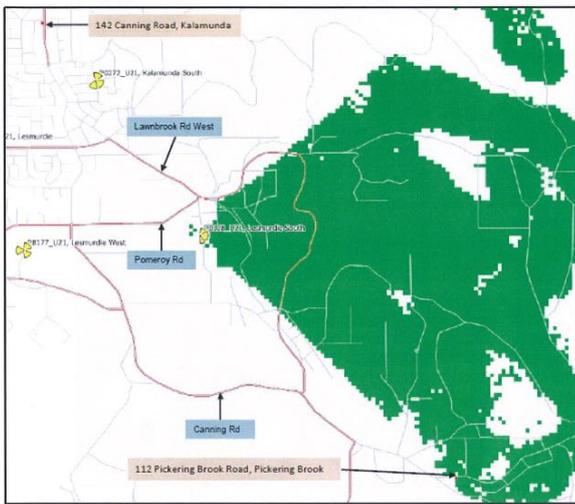
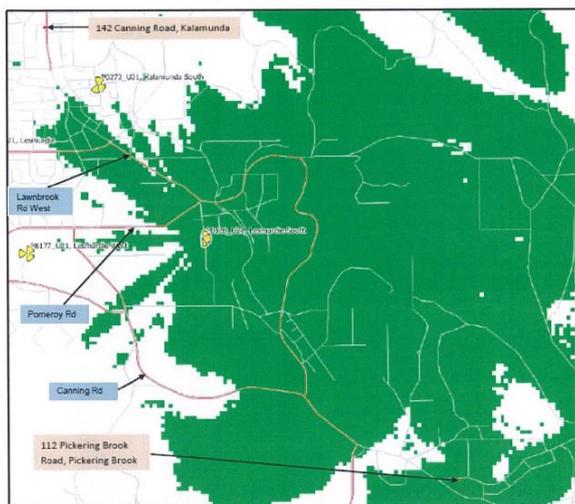


Figure 6: Plot showing Prediction of Possible Cell Coverage Area for “Lesmurdie South-O:P0128-OU21-A-2” on 26/10/2013.



Several members of Telco staff were called as witnesses. It became clear, as they gave evidence, that there was no factual underpinning to the claims that the software tool used to predict tower coverage had been validated by field tests. It was asserted by a Telco witness that the Telco had provided hundreds of such coverage maps over the last decade, but this was the first time (late 2015) that they had been challenged.

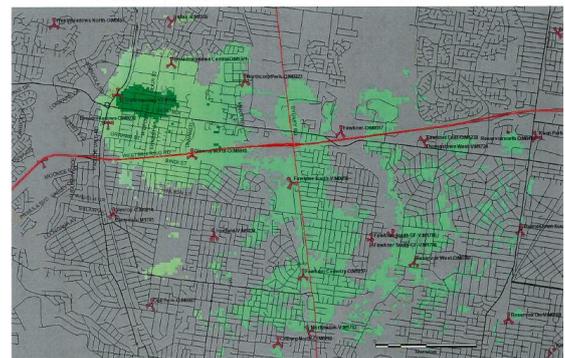
It is important to grasp that coverage maps are based on a *theoretical prediction*. The actual tower coverage has to be checked by field testing with appropriate equipment (e.g. a scanner, not a mobile telephone – see Figures B4 and B5 below). Moreover, it does not follow from street testing that ‘indoor’ coverage will be the same.

Below are shown a number of the coverage maps produced in the Telco evidence, including one (Figure B3) showing where the defendant was alleged to have been at the time of the call of interest. The first observation from Figure B3 is that the Telco evidence does not put the crime scene (Nepean Street) in the dominance region for the Broadmeadows site, which is where the Crown suggests the accused made the call from the CCR data.

### Another case of misuse of coverage maps

Maps from the Telco based on their software prediction tool were initially presented by the Crown as evidence that the accused was at the crime scene. On the trial within a trial (*voir dire*), the prosecution first contended that *both* CCRs and coverage maps could be admitted as business records. The CCRs can be business records; however, it was argued for the defence that the evidential weight of the coverage maps depended on their measured reliability. Opinions as to the strengths and weaknesses of these coverage maps are matters of expert opinion.

Figure 1: Prediction of Probable (dark green) and Possible (light green) Cell Coverage area for Broadmeadows-V M1738-OU21-A-2 Cell ID 12535 on 21122014



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Figure B1: Probable and predicted coverage for Broadmeadows

# Problems with cell phone evidence tendered to 'prove' the location of a person at a point in time

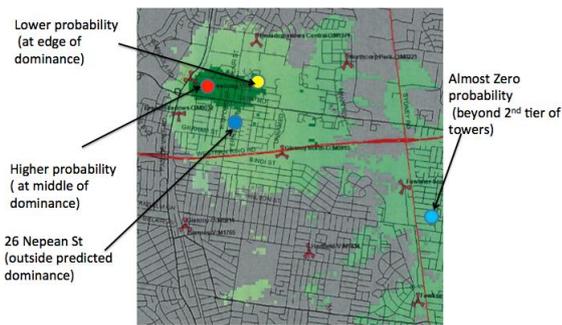


Figure B2: Broadmeadows coverage 'evidence'

Figure 2: Prediction of Probable (dark green) and Possible (light green) Cell Coverage area for Glenroy North-O M0910-OU21-A-1 Cell ID 15534 on 21122014

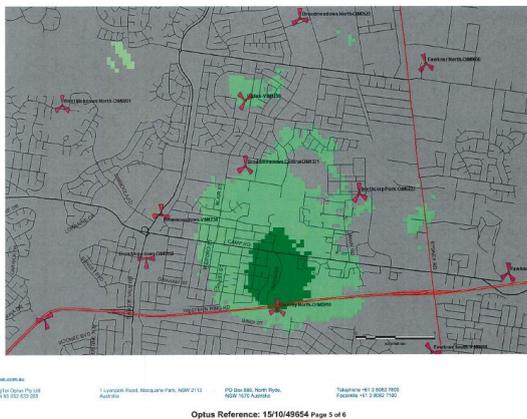


Figure B3: Probable and predicted coverage for Glenroy South

Figure 1: Validation Results from field tests (Overlay on Prediction plots). Probable (dark green line) and Possible (light green line) for Broadmeadows-V M1739-OU21-A-2 Cell ID 15235. Solid black line indicates dominance of other Optus cells in the area.



Figure B4: 'Validated' dominant coverage for Broadmeadows

Figure 2: Validation Results from field tests (Overlay on Prediction plots). Probable (dark green line) and Possible (light green line) for Glenroy North-O M0910-OU21-A-1 Cell ID 15534. Solid black line indicates dominance of other Optus cells in the area.

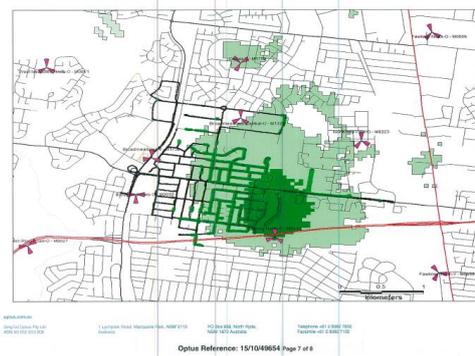


Figure B5: 'Validated' dominant coverage for Glenroy South

## Incorrect information about coverage; misuse of 'consistent with'

An area map showed the location of the base stations and associated Cell ID. There were no coverage maps available. A prosecution expert opined that certain matters were 'consistent with'. This is misleading. Such a statement should not be allowed. The witness also made a technical error in asserting that the coverage of WCDMA and GSM900 are similar. In fact, the typical coverage areas are different. GSM900 coverage is generally greater than WCDMA, but is strictly less than 35km due to the TDMA time slot limitation (see the explanation in footnote 13).

## Misuse of the phrase 'consistent with' to suggest 'supportive of'

An area map showed the location of the base stations and associated Cell ID. The expert witness used the words 'consistent with' to infer that the defendant was at the crime scene. This was very weak evidence, and no coverage maps were provided which could have assisted this interpretation.

## Evaluating competing hypotheses

In another case before a Coroners Inquest, the police alleged suicide, but the parents of the deceased thought it was murder. The Coroner returned an open finding (i.e. rejecting the police view that it was suicide). The Telco provided CCRs, along with coverage prediction information (i.e. maps) from their engineering group. An area map showing the location of the Telco base stations was provided; however, associated Cell IDs were not provided – even after several requests.

The expert had to use 'radial coverage estimation', noting the significant differences in the coverage of signals between 3G and GSM. None of the calls of

interest could have originated at the person of interest’s declared position without a catastrophic failure of the transmission towers. There was no such failure. The calls were, therefore, more likely to have been made in the area of the deceased’s home.

### Evaluating alternate hypotheses

An employee was provided with a mobile telephone by his employer. He claimed that he was in bed on a particular date in the care of his mother-in-law recovering from an accident that was the basis of a workers compensation claim. However, this claim did not accord with the Telco record of calls from his mobile at the time.

The investigation tested the claims made by the parties under the ‘balance of probability’ that the mobile telephone on that day was on the move rather than stationary beside his bed. The Telco did not provide detailed CCR records. The records actually provided gave no additional information other than the bill. While the Telco has been unwilling to provide reasons, it is assumed that it restricted the detail because it was a civil, not a criminal case.

### Testing an hypothesis

A data session was intended to confirm the location of a user who claimed to be in one location (‘A’). The data session based on the CCR identified the location of the mobile (‘B’) to be over 20 km away from ‘A’ (roughly an hour to drive). The claimant suggested that the session started from location ‘B’ and ended in location ‘A’. Our analysis of the data session, given the recorded data volume of 24 kbytes, and using very conservative download speeds, suggested it was very unlikely that the session that started in location ‘B’ ended in location ‘A’. The minimum download speeds of mobile networks is in the order of 32 kbps. A simple calculation to calculate the download duration is:

$$\text{DownloadDuration} = \frac{\text{DataVolume} \times \text{OverheadFactor}}{\text{MinDownloadSpeed}}$$

Using an overhead factor of 2 we have:

$$\text{Download Duration} = (24 \text{ kbytes} \times 8 \text{ bits per byte}) \times 2 / 32 \text{ kbit/s} = 12 \text{ seconds}$$

Over a duration of 12 seconds, the user probably started and ended the session in the same cell or just one cell change away.

### Final comment

Our purpose in writing this article has been to give litigation lawyers sufficient understanding of what can be done with CCRs and software propagation maps to alert them to the dangers of misuse. Our experience is that such misuse is too common. Whether you are defending or prosecuting, please ensure that you do not become ‘part of the problem’. Select your supposed expert with care. Be alert to so called experts who lack the training and the depth of experience, but are prepared to proffer such baseless observations as ‘consistent with’.

Be sure to provide all necessary data and sufficient time for a proper analysis of that data to be made. This is a complex area of expertise, often requiring much experience and time before a reliable opinion can be stated.

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