

Cell Site Analysis and Expert Opinion

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1. Expert Witness Declaration of Understanding

- 1.1. This report has been compiled from information provided to me by Omagh Bombing Inquiry. I reserve the right to re-examine my findings should any of the information furnished be incorrect or be the subject of change at any time in the future.
- 1.2. I, Dr Matthew Stephen Tart, am an expert in Cell Site Analysis and I have been requested to provide an analysis and statement. I produce my Report in accordance with Part 35 of the Civil Procedure Rules and in the knowledge that my evidence is impartial and independent.
- 1.3. In accordance with my duties of revelation, as documented in the guidance booklet, I Dr Matthew Stephen Tart DECLARE THAT:
 - 1.3.1. I understand that my duty is to help the Chairman to achieve the overriding objective by giving independent assistance by way of objective, unbiased opinion on matters within my expertise, both in preparing reports and giving oral evidence. I confirm that I have complied with and will continue to comply with that duty.
 - 1.3.2. I confirm that I have not entered into any arrangement where the amount or payment of my fees is in any way dependent on the outcome of the case.
 - 1.3.3. I know of no conflict of interest of any kind, other than any which I have disclosed in my report.
 - 1.3.4. I do not consider that any interest which I have disclosed affects my suitability as an expert witness on any issues on which I have given evidence.
 - 1.3.5. I have shown the sources of all information I have used.
 - 1.3.6. I have exercised reasonable care and skill in order to be accurate and complete in preparing this report.
 - 1.3.7. I have endeavoured to include in my report those matters, of which I have knowledge or of which I have been made aware, that might adversely affect the validity of my opinion. I have clearly stated any qualifications to my opinion.
 - 1.3.8. I will notify those instructing me immediately and confirm in writing if for any reason my existing report requires any correction or qualification.
- 1.4. I understand that:
 - 1.4.1. My report will form the evidence to be given under oath or affirmation and I may be required to attend to give oral evidence to the Inquiry.
- 1.5. CCL hold UKAS accreditation for Cell Site Analysis.
- 1.6. I confirm that the contents of this report are true to the best of my knowledge and belief and that I make this report knowing that, if it is tendered in evidence, I would be liable to prosecution if I have wilfully stated anything which I know to be false or that I do not believe to be true.
- 1.7. I confirm that I have made clear which facts and matters referred to in this report are within my own knowledge and which are not. Those that are within my own knowledge I confirm to be true.

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2. Author Background

- 2.1. I am Dr Matthew Tart FCSFS, a trained forensic scientist with expertise in the field of "Cell Site Analysis" and the interpretation of telecommunications data. I undertake work for both Defence and Prosecution and am independent of both. I confirm that I abide by the requirements of Criminal Practice Directions and Criminal Procedure Rules in the production of this report. I use validated methods and undertake regular competence assessments for my role. My academic qualifications and professional membership include:
- i) B.Sc. (Hons) in Applied Physics.
 - ii) PhD, with my Doctoral Thesis on "Forensic Inference from Telecommunication Records".
 - iii) Fellow of the Chartered Society of Forensic Sciences (FCSFS).
- 2.2. I have been a Forensic Scientist since 1993, initially joining the UK Home Office Forensic Science Service, immediately followed by CCL Forensics from 2010. Within this period:
- i) 1993-1997; FSS R&D. Physical Sciences Group. Research Scientist.
 - ii) 1997-2001; FSS R&D. Digital Group. Research Scientist.
 - iii) 2001-2003; FSS National Development Manager, High-Tech Casework.
 - iv) 2003-2010; FSS Expert Witness/ R&D, Digital Evidence. Senior Forensic Scientist.
 - v) 2010-date; CCL Expert Witness/ R&D, Cell Site Analysis. Principal Expert.
- 2.3. My training encompasses areas including assessment of uncertainty, use of forensic inference models and technical knowledge or skills relevant to specific areas of casework (e.g. telecommunication network operation or use of specific survey or mapping tools).
- 2.4. I routinely conduct R&D in the field. I am lead author on a range of scientific papers, primarily published in Elsevier's Q1 international journals "Science and Justice" and "Digital Investigation", collectively forming much of the academic foundation for Cell Site Analysis.
- i) I hold a "PW Allen Commendation" from the Chartered Society of Forensic Sciences for my paper "Opinion Evidence in Cell Site Analysis" as one of the "most meritorious" in forensic science that year based on "impact, novelty and the quality of the science".
- 2.5. I am focussed on Quality and standards, from detailed local application (developing, validating and implementing Methods and Competency Frameworks) to advising on the Home Office Forensic Science Regulator (FSR) Codes and International Standards (ISO 21043).
- i) I chaired the Cell Site Analysis sub-group (part of the Digital Evidence Group) advising on the development of the FSR Codes: FSR-C-135 "Appendix: Cell Site Analysis"
 - ii) I was a member of the group generating the consultation draft of FSR-G-218 "Method Validation in Digital Forensics".
 - iii) I am a member of the FSR Interpretation Group delivering guidance for forensic inference (FSR-GUI-0004) and lead the sub-group for Cell Site Analysis for this aspect.
 - iv) I am a member of the British Standards Institute Forensic Science Module (BSI FSM/1).
- 2.6. I actively engage with the Forensic Science Community for example the Chartered Society of Forensic Sciences (CSFS), the Royal Statistical Society (RSS), Law Enforcement, for example via the Forensic Capability Network (FCN) and Practitioners (e.g. via the College of Policing).
- i) I am author of the "Cell Site Analysis" chapter in the Major Reference Work "*Elsevier Encyclopedia of Forensic Science (3rd Edition)*".

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3. Information and Data Received

- 3.1. I outline the material I have considered in the additional document "[**INQ042461**] References". This material includes references (for example academic, legal, regulatory or technical specifications) and the Inquiry-specific material with which I have been provided.

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4. Purpose

- 4.1. I have been instructed to prepare an expert report to provide an overview of the technical capabilities that the police and law enforcement authorities in Great Britain, Northern Ireland and the Republic of Ireland had to track and analyse mobile phone activity in the period between 1997 and the date of the Omagh Bombing on 15 August 1998.
- 4.2. I have been commissioned by Omagh Bombing Inquiry to:
- 4.2.1. Provide an explanation of the data that Telecommunications Service Providers (TSPs) obtained and retained in relation to mobile telephone usage in 1997 and 1998 and for how long they commonly retained it.
- i) Explain whether there is any reason to doubt the accuracy of the data that was retained by TSPs in 1997 and 1998.
 - ii) If TSPs obtained and retained cell site data, please explain the process of cell site analysis and what it would have been capable of showing in 1997 and 1998.
 - iii) If cell site data was retained, please explain whether the authorities were able to access it in 1997 and 1998 and, if so, how quickly.
- 4.2.2. Explain how the user of a mobile telephone might have been identified in 1997 and 1998, whether through a subscriber check, IMEI number identification, call pattern analysis, home cell site analysis or in any other way.
- 4.2.3. Explain whether the authorities in 1997 and 1998 had the ability to access text messages (and similar) and voicemails made and/or received by mobile telephones, and whether that was dependent on having access to the handset itself.
- 4.2.4. Provide context to the mobile phone technology that was available during the relevant period from 1997 to 15th August 1998.

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5. Approach Taken & Caveats

5.1. My expertise is focussed on Cell Site Analysis conducted on call data from 2003. I have a detailed understanding of how cell site analysis has been conducted since that year, with direct and extensive experience of research, development, validation (including external review of processes and extensive testing against Ground Truth Data), competence testing, casework and the legal/ regulatory context. I was not directly involved in telecommunications (either in the industry or forensic analysis of traces from it) in 1997-1998 and some of the questions rely on knowledge that predates my direct knowledge. For example, I do not have direct knowledge of:

- i) The TACS analogue mobile phone system available in the Republic of Ireland / Northern Ireland in 1997-1998 (which had been phased out prior to 2003).
- ii) Many elements of telecommunication systems not relating to ascertaining the area in which a device was operating (e.g. protocols for accessing call data prior to 2003).
- iii) Legal processes performed from within Policing in prior to 2003.
- iv) Specific practices in Cell Site Analysis in prior to 2003.

5.2. I have therefore considered additional sources of information to answer the questions and have treated this exercise as I would if I were submitting a paper to a scientific journal. The sources are listed in "INQ042461 References", which I refer to from this point forward as just "references".

5.3. Where I have obtained information that enables me to confidently answer the questions raised, I provide a reference to its source. If I am unable to confidently fully address a given question, I highlight the approach I took in the attempt.

5.4. I also compare, where appropriate, current practice in forensic cell site analysis with that which was undertaken in 1997-1998. There is obviously no expectation that the work undertaken in 1997-1998 would have complied with current legislative and regulatory requirements or accommodate research material introduced or made available after its commission, but I do make comment if practices used at the time of the investigation were later identified as unsound.

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5.5. Contemporaneous statutory requirements at their core have the following guiding principles:

5.5.1. Balance – The expert should address at least one pair of propositions usually one based upon the prosecution issue and one based upon an alternative (defence issue). If a reasonable alternative cannot be identified then the expert may address only the one proposition but will make it clear that he cannot evaluate the strength of the evidence.

5.5.2. Logic – The expert will address the probability of the *evidence* given the proposition and relevant background information and not the probability of the *proposition* given the evidence and background information. Equating these different probabilities is known as a Transposed Conditional or “the Prosecutors Fallacy”.

5.5.3. Robustness – The expert will provide opinion that is capable of scrutiny by other experts and cross-examination. They will base opinion upon sound knowledge of the evidence type(s) and use wherever possible verified databases. They will be satisfied that the results of the tests and examinations upon which they have based their opinion are themselves robust, meaning that:

- i) Methods are defined and validated.
- ii) Competencies are defined and tested.
- iii) Quality Assurance, including checking of technical detail and opinion, is defined and has been conducted.

5.5.4. Transparency – The expert will be able to demonstrate how they came to their conclusion.

They will set out in the statement or report the basis of their opinion viz.:

- i) Propositions addressed.
- ii) Test or examination results.
- iii) The background information he has used in arriving at his conclusion.
- iv) They will be able, if required, to provide the data used and its provenance.

I do not expect casework from over 25 years ago to be in full compliance with contemporaneous requirements (as discussed later in this report, some weren't even defined in 1998); I have reviewed the evidence received through this lens so that if there are any obvious issues with reliability they can be identified.

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6. Mobile Phone Technology and Cell Site Analysis

6.1. In discussing Cell Site Analysis capabilities relevant to the Omagh Bombing, in my view it is useful to refer to current practice and capabilities so that the "gaps" (and therefore risks or potentially missed opportunities in the cell site evidence of the time) can be better understood. This section also details limitations to my confidence in some of the questions I have addressed. To perform Cell Site Analysis effectively, essential requirements are:

- 6.1.1. Access to Call Data, detailing times of cell usage,
- 6.1.2. Cell information (at minimum the location of mast, with preferably more detailed information such as azimuth, height etc.). This may be supplemented with survey data if required,
- 6.1.3. Technical knowledge and skills to understand and combine the call data and network information, generate maps etc.,
- 6.1.4. Technical understanding to enable assessments of cell service areas, or time uncertainties in the call data etc.,
- 6.1.5. Forensic Understanding to enable reliable opinion to be given concerning the meaning of the call data in the context of the questions arising.

General Overview - Presentation

Please refer to **MST/Cell_Site_Analysis_**INQ035079 I provide an overview of Cell Site Analysis on GSM call data (only GSM was in the call data considered from the Omagh investigation, and that contained only voice calls and text messages). The presentation applies both to the time of the Omagh investigation and current practice (as it is still a technology in use by the networks). This presentation is intended as a high level overview, I provide more detail concerning those aspects that I have been asked specific questions on (i.e. practice 1997-1998) in the later named sections on toll tickets (content, accuracy, access and retention) and cell site analysis.

6.2. Slide 2. **Mobile Phones.**

A mobile phone is a two-way radio and consists of a SIM card and a handset.

- i) The SIM card ('Subscriber Identity Module') contains data relating to the subscriber including a unique number (the International Mobile Subscriber Identity, or IMSI) that can identify the phone to the network. The network associates a telephone number (the MSISDN) with the IMSI.
- ii) The handset is a small computer and radio that lets the SIM card 'talk' to the mobile phone network. The handset does not have a phone number of its own and cannot make

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chargeable calls without a SIM card. The handset has a unique serial number (the IMEI) that can identify it to the network.

IMEI. As of 2004 the format of the IMEI is AA-BBBBBB-CCCCC-D where AA-BBBBBB (the Type Allocation Code) identifies the manufacturer/ model of device and CCCCC is the serial number. Additional digits are routinely added to the 14-digit IMEI as:

- i) IMEI with Check Digit: AA-BBBBBB-CCCCC-D where D is a checksum which is used to check the first 14 digits are valid.
- ii) IMEISV. AA-BBBBBB-CCCCC-EE where EE is the Software Version of the handset. Prior to 2002, the TAC was six digits long and was followed by a two-digit Final Assembly Code (FAC), which was a manufacturer-specific code indicating the location of the device's construction.

IMSI. IMSI stands for International Mobile Subscriber Identity. It is a number which is used to identify a specific mobile subscriber. The IMSI number is used by the network to relate the mobile telephone to a telephone number or numbers. The IMSI is unique to each SIM card but which phone number is associated with it is held centrally by the network; phone numbers are referred to as MSISDNs, or Mobile Station International Subscriber Directory Number). The IMSI is typically 15 digits long and consists of three parts:

- iii) Mobile Country Code (e.g. "234" for the UK).
- iv) Mobile Network Code (e.g. "15" for Vodafone UK).
- v) Mobile Subscriber Identification Number (assigned by the network unique to the subscriber).

Networks issue their own SIM Cards, but in 1997-1998 these were sold to customers by resellers (paragraph 4 of **INQ027082**). A handset containing a given network's SIM card will usually, but not always, be locked to using that network.

- i) It may be possible to make emergency calls if a phone is not able to connect to its home network. Such calls are not charged for.
- ii) Phones can also roam to other networks which have an agreement in place (I discuss "roaming" in more detail in section 6.12, as it is relevant to the questions addressed).

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6.3. Slide 3. **The network.**

When a call is made on a mobile phone, the phone does not directly contact the other person. It communicates with the mobile phone network (e.g. Vodafone). The network then passes the information through to the desired destination using a core network of computers.

- i) When a mobile phone makes or receives a call or text message it makes a radio connection to the phone company's network via a cell site.
- ii) Cell sites are linked to the mobile phone network and the call is then routed to its destination by the core network.
- iii) The destination may have been another mobile phone or a land line phone.

The Core network consists of many computers, phone exchanges and other equipment linked together, and these elements can produce call billing records (seen by the user) and more detailed Call Data Records (used in cell Site Analysis).

6.4. Slide 4. **The role of the MSC.**

A network consists of many cell sites. Another term for "cell site" when using GSM is a "Base Transceiver Station" (BTS), which is often shortened to "Base Station". Groups of Base Stations are controlled by a Base Station Controller (BSC), which helps maintain the connection between the handset and the network by "handing over" calls between different BTS as a mobile phone moves, due to network loading, or because better service may be offered by an alternative Cell. Collectively, the Base Stations and Base Station Controllers are termed the "Base Station Subsystem" (BSS).

The Mobile Switching Centre (MSC). The MSC's primary function is to act as a centralized hub for voice and data traffic switching and routing inside a mobile network. It is a gateway between the mobile network and other networks to communicate smoothly between mobile subscribers and users on various networks. The Home Location Register (HLR) is separate to the MSC and stores and manages subscriber information, including phone numbers and service subscriptions. The Visitor Location Register (VLR) is separate to the MSC and keeps transient records of phones that are active on the network including the general area in which the phone was last known to be (the "Location Area"). The Authentication Centre is separate to the MSC and, as the name implies, authenticates and authorises subscribers using the network.

6.5. Slide 5. **Billing.**

Billing encompasses several key processes: Collecting subscriber usage data for subscribed services, aggregating usage data over a fixed time period, applying rental charges, generating invoices, managing payments and recording payment history. Detail of connections are recorded so that the phone user can be charged. The billing is focussed on the number called

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(e.g. identifying premium rate numbers), length of a call, the number of text messages, but other information can also be also recorded (for example cell site information). The system produces call billing records (seen by the user) but it is also possible to produce more detailed records which include the extra information that is then repurposed for use in Cell Site Analysis such as which cell was used to handle the call. With appropriate legal authority, these records can be requested, and inferences made as to where a phone may have been. The content - the actual voice call or text message - is not recorded in this process.

6.6. Slide 6. **Cell Sites.**

A mobile phone network consists of a large number of radio stations (called "Cell Sites"), all of them sending out signals to help a mobile phone recognise which is the 'best' radio station to use at a given time.

- i) UK mobile Network Operators have many thousands of sites often housing several sets of transmitting / receiving equipment.
- ii) These are designed to provide a good quality of service often with overlapping coverage and come in many forms, intended for different environments.
- iii) Tall masts tend to be in rural areas and have bigger service areas than small masts in dense urban environments.
- iv) The place where the radio station is based (i.e. where the aerial and radio equipment are) is called a cell site. There may be more than one antenna at a given cell site (i.e. there is usually more than one cell based at any cell site, usually pointed in different directions from it).

6.7. Slide 7. **Sectors.**

Often the equipment for several cells (usually three) are located on the same mast or building.

- i) Such co-sited cells are known as 'sectors' and each sector usually point in a different direction. This direction is indicated by a compass bearing (the azimuth) with, for example, 0° representing north, 90° east, 180° south and 270° west. The different sectors operate independently from the others on the same site and may serve different geographical areas.
- ii) Each one of these Cells is given a number, called a Cell ID, which is unique to a given network/ technology/ area.
- iii) The area over which that Cell ID is selected for service by a mobile device (i.e. the area which it serves) is called a Cell.

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- iv) Some sites may not have sectors, but be a single aerial transmitting and receiving in all directions. These are called "Omnicells". They are rare contemporaneously, but from the data considered appear to have been more prevalent in 1997-1998.
- v) I am also informed, by my colleague Dr Brodie, that some cells near coasts or international borders may be configured with a single but directional antenna pointed inward (i.e. away from the sea or international boundary to limit service in those directions).

6.8. Slide 8. **Cells.**

The shapes of service areas for each sector will almost always be irregular. A cell's service area depends on factors such as the height of the cell site antenna, the direction in which it is pointed, its power, the location of other cells, the geography of the terrain (hills), obstructions such as buildings and cell site density in the area (i.e. presence or absence of other cells)

- i) Radio signals are attenuated by buildings or hills. Cell sizes can therefore be reduced by the terrain or buildings around them as the signals get worse. The height of the antenna compared to its surroundings is therefore important. The signal also gets quieter the further a phone is from the mast. At any given time, the phone doesn't know where it is, or where the nearest cell site is, but it does know which cells it can 'hear' the best and can compare them. It selects the 'best' cell according to how loud it can hear it relative to the others, but it can also be influenced by other factors according to how the network has been built and which cell it has previously selected. A mobile phone may not therefore connect to the closest cell site, and different phones at the same location may select different cells.
- ii) A single Cell ID can only support a limited number of calls at a given time, so areas where there are likely to be more calls (e.g. city centres) usually have more cell sites than areas where there are likely to be fewer calls (e.g. rural areas). More cell sites give a phone more options as to which is best and if the phone is moving it can get closer or further away from local cell sites quicker; it might therefore reselect cells more quickly as well. Cells in city centres are therefore usually smaller than those in rural areas. For example, INQ028453, p11 lists an expectation of Cell service for the "Omagh Technical College" cell as less than 7km (rather than 35km from the mast for "Pigeon Top" (paragraph 4.4).
- iii) A phone can change cells while in-call, or for successive calls, without moving if the cells used provide overlapping service where the phone is located; usage of different cell sites over a period of time does not necessarily demonstrate movement. This was well understood from the data I have reviewed.

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6.9. Slide 9. **Surveys.**

A radio survey can provide an estimate of an area in which – as an opinion – it is reasonable a phone may have been at the time of its call activity. Likewise, the area over which a cell provided service at the time of the call is not known. The expected service area can be estimated based on information available which may include the height of the mast, point direction (azimuth) of the cell used, local terrain and “clutter” (buildings, forests etc.) and presence or absence of other cells. As part of this process, survey data may be used. The purpose of a survey is to measure which cells are selected by survey equipment in a given area of interest on the day of the survey. Survey data can therefore provide clarity as to:

- i) Whether a cell served at a location of interest at the time of the survey.
- ii) The general area over which the cell also served (a small cell is more discriminating as to where the phone may have been than a large cell).

Cell service areas may change over time as sites are decommissioned, reconfigured or introduced, and there may have been a change in the environment - e.g. the construction or demolition of tall buildings - between the time of the call and the survey. Within the slide itself:

- iii) The image on the left represents the locations in which service has been detected by a rural cell (purple) and a suburban cell (brown). The grey dots represent survey readings where neither of these cells were selected for service.
- iv) Radio signals are attenuated by buildings or hills. Cell sizes can therefore be reduced by the terrain or buildings around them as the signals get worse. The height of the antenna compared to its surroundings is therefore important. The signal also reduces the further a phone is from the mast. As a result of these factors:
 - a) Cell shapes and sizes will vary, and the closest cell site will not necessarily be that selected by the phone.
 - b) Rural cells tend to be larger (and therefore less discriminating) than suburban cells, as can be seen in the example given.

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6.10. Slide 10. **Toll Tickets.**

When a call is made or received, the network usually records the Cell site (and Cell ID) along with other information such as the type of activity (e.g. call or text), the duration, date, time and the number with which it was in contact. The azimuth (the direction in which a given Cell ID was pointed) may also be recorded in current CDRs but was not included in the data I have reviewed. The specific location of the phone is not in the Call Data. The equipment (i.e. the cell) to which it was connected at the time of signalling activity is available, however. From this, an estimate of an area in which the phone may have been at the time of the call activity can be made as previously outlined. From the data, a given event may provide the Cell ID used and the location of the mast (i.e. the cell site). There is no indication of specifically where the phone was within the service area of the cell it used. On a sectorised cell, the area over which all sectors provide service is obviously going to be much greater than the area over which just one does. In the absence of azimuth information we are forced to amalgamate the estimations of all sectors when estimating the area in which the phone may have been. This reduces the precision of estimations on the area in which a phone may have been when using a cell on a given cell site, and is the equivalent of treating every cell site as an omni-cell.

6.11. Slide 11. **"Modern" CDRs.**

The provision of Call Data has evolved considerably over the last 25 years. Current CDRs routinely include azimuth information, end cell data and the co-ordinates of the cell sites used. The fundamental limitation that there is no indication of specifically where the phone was within the service area of the cell it used remains for contemporaneous CDRs used for historical cell site analysis. The potential improvement in precision afforded by modern CDRs arises because the service areas of modern sectorised cells are much smaller than cells in 1998, we routinely have azimuth information. There are also often far more call events available to consider now (e.g. because of data events but also end cell information); more informed opinion concerning a phone's location or movement can be made in periods when multiple cells are used.

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Roaming

- 6.12. If a mobile phone cannot 'hear' any cells from its own network (e.g. if the phone is on the Vodafone network but there is no Vodafone coverage) it will listen for cells from other networks. If it finds one, it will not necessarily be able to make a chargeable call, but it may be able to contact the emergency services (Police, Ambulance etc.). One network will usually not let a phone from another network in the same country make a chargeable call through it, for example in the UK a phone on Vodafone will not be able to make anything but emergency calls on a different network. The SIM card has a list of those mobile phone networks it cannot use (called the 'forbidden network list') and can tell which network owns a given cell from the information transmitted by it.
- 6.13. If, however, the phone is in another country, the cells it will listen to will not be from operators on its 'forbidden network' list. In such a case it may make contact with the network it hears and, if there is an agreement between the foreign network operator and the 'home' network on which the phone is contracted, it may use the new network - for a fee. This is called 'International roaming'. For example, a phone on the UK Vodafone network in Northern Ireland may be in the Republic of Ireland (where there is no coverage from Vodafone) and roam - historically onto Eircell, for example. Likewise, an Eircell phone may have come to the UK and elected to use the Vodafone network. In this way someone may be able to take and use their phone while on holiday or business abroad. These agreements mean that it is sometimes possible for phones on the South Coast of England to be able to use cells on French networks based in France, or a phone from the Republic of Ireland to use cells based in northern Ireland.
- 6.14. The SIM may also have a preferred a network list for the country in which it is used, so the phone will roam onto one network more readily than another.
- 6.15. The Call Data can still be requested as before, but the data may be more limited than if it were used in its home country (for example the record may merely note the foreign network name which is being used, or that the cell site used to handle the call is in Spain etc.). Some networks may provide similar levels of detail as a UK network, potentially including a precise location of the used cell site. This data is called "TAP" (Transfer Account Procedure) data. From personal experience since 2003 of international roaming data, the amount of detail available is network dependent; some roamed networks provide as much detail as in a "home" CDR, others provide the call details but without cell site details, merely stating which network was used to handle the event.

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6.16. The material considered included roaming agreements, for example in INQ000719 (ESAT Digifone with Cellnet), INQ000720 (Eircell with Cellnet), INQ000742 (ESAT Digifone with Vodafone), INQ000744 (Eircell with Vodafone).

7. Changes in the Context within which Cell Site Analysis is conducted

7.1. At the time of issue of this report, Cell Site Analysis is a commonplace activity. While it has been used in court for decades, usage has become far more widespread in the UK for the last 10 years. Tools are available automating some technical elements, training is available, research has been published and (in England and Wales) regulatory requirements have been implemented (a "Forensic Science Activity" detailing expectations for sound practice backed by statutory powers). The context within which cell site analysis is currently conducted has therefore changed dramatically since 1997-1998.

7.2. To my knowledge, R v Steele (1995) was the first usage of cell site analysis in open court. Findings were presented at a trial at the Central Criminal Court which I understand began on 1 September 1997 and ended on 20 January 1998. I am aware that Cell Site Analysis was also used in the Manchester Bombing (1992) which I do not believe lead to charges or prosecutions and so was not presented in evidence. I discuss these cases later in this report.

7.3. I was aware of the use of Cell Site Analysis in R v Steel when scoping the FSS offering in 2001. I only became aware of its use for the Manchester Bombing as a result of material I have considered for this Inquiry. I do not know how Cell Site Analysis was applied to investigative use in Northern Ireland or the Republic of Ireland in this period, or indeed anywhere else. I am aware that Cell Site Analysis was deemed sensitive and as such my role outside Policing (I was in the Home Office Forensic Science Service in this period) did not expose me to them. It is my understanding that usage of Cell Site Analysis in the Omagh Bombing was one of the earliest uses of the method, possibly even at an international level.

7.4. I have spent much of my career developing, validating, implementing and delivering case material resulting from novel methods. I first became directly involved in Cell Site Analysis in approximately 2001, as part of a scoping exercise when I was the Forensic Science Service National Development Manager for High-Tech Casework. The role encompassed developing capability and capacity for the digital forensic service of the FSS. Cell Site Analysis was provided as an evidential service by a small number of private companies in the UK at that time. My belief in 2001 was that the field was in its infancy, and I generated a project proposal to develop and validate methods. It took a number of years to do so as it involved external recruitment and we were also developing other services in parallel. I became heavily involved in the technical

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development of methods from 2003. I was the first expert in the FSS to take a cell site analysis case to court. The required processes for delivering a new service from within the FSS included the following:

- 7.4.1. The methods had been developed, validated and documented.
- 7.4.2. Competencies were defined and tested. This included for the required:
 - i) Skills; use of survey equipment, processing call data, mapping etc.,
 - ii) Technical knowledge; at that time understanding of GSM and UMTS, and
 - iii) Understanding; use of an inference model, the Case Assessment and Interpretation Model.
- 7.4.3. Quality Assurance processes were in place, e.g. report checking, equipment testing etc.
- 7.4.4. Blind trials had taken place. A third party made calls, recorded where they were, and the raw call data requested. These were submitted a mock case. A casefile was prepared and analysis conducted accordingly. This exercise culminated in a "mock witness box exercise" where the true location was known by others but not by the practitioner. This tested the process from end to end, including the overall competence of the expert.
- 7.4.5. The entirety of the process was reviewed by the Forensic Science Service Chief Scientist and approved for use in casework. In addition, the technical methods had been reviewed by an external expert (Professor Costas Constantinou at the University of Birmingham).
- 7.4.6. In essence the service complied with current requirements as defined in section 5.5; prior to implementation the service was demonstrably balanced, logical, robust and transparent.
- 7.5. The methods that were independently developed and adopted by the FSS and used at the beginning of my casework career were not the same as those that were used contemporaneously by other providers. For example there was widespread usage of the "spot sample" survey method (use of which is not present in the specific casework material that I have reviewed for the Omagh bombing). This method had failed validation at the FSS and so had not been adopted. Usage of spot samples by other "mainstream" providers continued for many years and only really ended when it was discredited in the academic literature discussed in section 7.11..
- 7.6. There was no national standard in place for the delivery of Cell Site Analysis until 2016, and other organisations were not obliged to follow the approach taken for development of new services by the FSS. The Forensic Science Service (FSS) officially ceased all forensic casework and services to the criminal justice system on 31 March 2012. The cell site unit was disbanded prior to 2012 (I was made redundant at the end of September 2010, for example). All three of

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the senior experts (Dr Brodie, Nick Gleed and myself) moved to CCL and continued our work in casework, research and standards from there. Other than at CCL, I have seen no evidence in my career that when I first conducted casework, and for many years afterward, the process as outlined in 7.4 was followed by anyone delivering casework outside the FSS/ CCL; I do not, however, know this for sure.

- 7.7. If validity of methods, competency of practitioner and a regime of Quality Assurance have not been established, this increases risk to the Criminal Justice System. This does not necessarily mean that the work is automatically “unreliable”, but the reliability is unknown and the detail of the analysis should in my view be tested in a way that would not be necessary if there were external assurance (e.g. UKAS accreditation, which is now a statutory requirement).
- 7.8. I have previously highlighted concerns with the manner in which Cell Site Analysis is currently conducted in written evidence to the House of Lords in:

MST_House_of_Lords

I have included this evidence as I believe that it is relevant when comparing the analyses for the Omagh bombing to current practice; not all progress has been positive and there was practice for Omagh that I think was very good. Many of the concerns that I have with provision of cell site analysis from 2006 up to and including the present day do not, in my view, apply to the product that I have reviewed for the Omagh Bombing. I discuss this in greater detail in my additional report which is focussed on the evidential material I have reviewed. I am providing this as information only about evidence I have submitted to the House of Lords; I understand that the doctrine of Parliamentary Privilege may mean I cannot be questioned outside of Parliament about this evidence, as presented to the House of Lords.

- 7.9. **Forensic Science Regulation.** In England and Wales, there has been a Forensic Science Regulator since 2008. In 1997-1998, there was no defined standard available to establish consistent sound practice of which I am aware.
- 7.9.1. Cell Site Analysis is defined in the Forensic Science Regulator (FSR) Code of Practice as a Forensic Science Activity (FSA) DIG-200. This was issued in 2023 and, since 02/10/2025, is enforceable by the FSR. [“references” 1.1 & 1.2]
- 7.9.2. DIG-200 is largely based on the FSR Appendix FSR-C-135 (“Appendix: Digital Forensics – Cell Site Analysis”) first issued in 2016. [“references” 1.3]. I am not aware of any standard, in the UK or otherwise, specifically for Cell Site Analysis existing prior to 2016.
- 7.9.3. Guidance concerning validation of digital methods – including Cell Site Analysis- was first issued in 2014. FSR-C-218. [“references” 1.4]

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- 7.9.4. Guidance concerning control of cognitive bias was first issued in 2015. FSR-C-217. ["references" 1.5]
- 7.9.5. Legal obligations were summarised and first issued in 2012. FSR-C-118. ["references" 1.6].
- 7.9.6. Guidance concerning evaluative opinion was first issued in 2021. FSR-C-118. This Guidance has been re- issued in January 2026 as part of the statutory Code in FSR-GUI-0004 ["references" 1.7]. While requirements surrounding evaluative opinion were already specified within the Forensic Science Activity Cell Site Analysis (DIG200), additional guidance for this specific activity in the context of FSR-GUI-0004 is currently the focus of an active working Group and is in the review stage at the time of issue of this report.
- 7.9.7. The first FSR Code of Practice and Conduct was issued in 2010. FSR-C-100. ["references" 1.8]
- 7.9.8. The Forensic Science Regulator only has jurisdiction over England and Wales. I understand that, from the Home Office document "Government response to the consultation on new statutory powers for the Forensic Science Regulator" dated July 2015 that "the Scottish and Northern Irish authorities follow the Regulator's standards on a voluntary basis". The first iteration of the FSR Code was issued in 2010.
https://assets.publishing.service.gov.uk/media/5a8002c5ed915d74e622bf2b/2015-07-15_-_Government_response_to_the_consultation_on_new_statutory.pdf.
- The Forensic Science Regulator does not have jurisdiction over the Republic of Ireland.
- 7.9.9. The FSR Code incorporates work published by the Forensic Science Service on the Case Assessment and Interpretation model. This model was also summarised as a voluntary "standard" by the Association of Forensic Science Providers in 2009 ["references" 1.19]. At this time, the Association of Forensic Science Providers (AFSP) consisted of the major providers of forensic science in the British Isles including the Home Office Forensic Science Service, LGC Forensics, Orchid Cellmark, Forensic Science Northern Ireland (FSNI), Forensic Science Ireland, Scottish Police Services Authority (SPSA) Forensic Services, and Key Forensic Services. I discuss inference in greater detail later in section 12.4 of this report. Requirements of the AFSP standard include those outlined in section 5.5, namely Balance, Logic, Robustness and Transparency. These four principles are at the core of the FSR Code and were overtly adopted by Forensic Science Northern Ireland (FSNI) & Forensic Science Ireland by 2009, even before the first issue of the FSR Code.
- 7.10. Prior to 2010, any Code of Practice and Conduct was organisation specific. For example, the Home Office Forensic Science Service (FSS) providing the vast majority of services to England and Wales (except in London until the FSS and the Metropolitan Police Laboratory were merged in 1996) first issued its Code of Practice in 1992. At the core of the FSS Code of Practice were

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independence/ impartiality, definition of processes, validation of methods, competence of experts and auditing including via accreditation by external agencies (NAMAS at the time, now UKAS); the FSS were the first organisation in the world to achieve accreditation under ISO17025. The FSS also had a Chief Scientist who, amongst other duties, reviewed and authorised new methods for use in casework. There was a Quality Team who monitored quality failures and made recommendations and set up casework trials using "Ground Truth Data" to monitor validity and consistency of practice within and between laboratories. When the FSS was closed (and ceased to deliver Cell Site Analysis) I was made redundant. The Code Of Practice was part of the training material from my initial Expert Witness ("EW1") Course and I was given permission to take it. I have scanned the document and produce it as:

MST_FSS Quality Policy and Code of Practice

I am not aware if a parallel Code of Practice was in place in any other organisation producing expert evidence to the court system (including in Northern Ireland) in 1997-1998.

7.11. **Academic support.** In 1997-1998, there was no academic work available to inform sound practice:

7.11.1. To my knowledge, the first formal scientifically peer-reviewed publication on Cell Site Analysis was "Historic Cell Site Analysis - Overview of Principles and Survey Methodologies", published in 2012 ["references" 1.8]. This paper provided an overview of the basic concepts of Cell Site Analysis along with experimental results demonstrating flaws with established methods commonly used in evidence - spot samples. I discuss survey methods used in the Omagh investigation in section 12.20 of this report; Spot samples were not used and the concerns raised in this paper do not apply.

7.11.2. Since 2012 there have been a range of additional papers on the subject covering many aspects of practice, including approaches to inference, competencies, validation, novel technical methods and specific technical information, for example uncertainties within call data ["references" 1.9 -1.17]. My Doctoral Thesis is on this subject; it was the first in the field and submitted after the Omagh investigation [1.18].

7.11.3. On top of work directly related to Cell Site Analysis, additional papers and guides defining approaches to safer inference have also been published since 1998 ["references" 1.19 - 1.26].

7.12. **Legal Context.** The legal context in which Telecommunication Providers operate and by which call data is obtained is different to the structure in place in 1997-1998.

7.12.1. I discuss access and retention of data used in the Omagh investigation in more detail in sections 10 and 11.

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- 7.12.2. RIPA. The Regulation of Investigatory Powers Act, covering the powers of public bodies to carry out investigations including telecommunications data was introduced in 2000 ["references" 1.27]. RIPA defined the use of Single Point of Contact (SPOC) system to enable appropriate and controlled access to communication data.
- 7.12.3. CrimPR and CPD. Criminal Procedure Rules and Criminal Practice Directions first came into force in 2005. The rules define (amongst other things) requirements for Expert evidence including tests for reliability validation and competence. ["references" 1.28 & 1.29].
- 7.12.4. Rulings. Rulings concerning Cell Site Analysis.
- i) 2006. R v Steele [2006] EWCA Crim 195 ["references" 1.30] includes reference to one of the first uses of Cell Site Analysis of which I am aware in 1995 (the "Rettendon" or "Range Rover" Murders). It flags the limitations of the technique as it was understood at the time (paragraphs 40-55). In short, signals are affected by obstructions (terrain and clutter), signal strengths from different cells can vary over short distances (a few feet), different phones in the same place and time can provide different results. A call is not necessarily routed through the closest cell site and one cannot say whether a call would be more likely to be routed to one cell site than another. Cells serve areas, and prediction plots can help estimate these areas but they do not/ cannot take into account all the other many variables to which the radio signals are subject. These limitations in my view apply to all of Cell Site Analysis, including the Omagh Bombing. I discuss the R v Steele in greater detail later in this report (section 11).
 - ii) 2009. INQ000253 Judgment of Mr Justice Morgan in the NI High Court [2009] NIQB 50. This document specifically concerns the Omagh Bombing and is useful answering the questions I have been asked. The Toll Tickets is [O16]1 are discussed (paragraph 36) along with additional data requests to BT Cellnet, Vodafone and Eircell. Disclosure of call data was under the Data Protection Act (paragraph 37). Data was held between 6 to 12 months (paragraph 38). Two experts gave evidence, Peter Uglow (who had supervised over 250 cell site reports) and Peter Brown (80 reports); it is implied from this document in conjunction with INQ000256 that this experience was prior to 2008 (and not necessarily prior to 1998). Analysis was conducted on 585 (Murphy), 980 (McDermott) and 430 (Traynor) all covered in this report but also 076 (not in this report). There were 2 numbers in [O16]1 that were not discussed - 132 & 259 (paragraph 45). 430 used Cellnet unlike 585 and 980 which were Eircell which could roam on the Vodafone network based in Northern Ireland. There is an extended discussion concerning the production of [O16]1. Cell Site Analysis had been conducted for the Lisburn bomb investigation in April 1998.

INQ027527

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- iii) 2011. INQ000256. Court of Appeal judgment [2011] NICA 33. This document specifically concerns the Omagh Bombing. Similar matters are discussed as in INQ000253, in particular surrounding provenance, reliability and admissibility of call data.
- iv) 2013. INQ000257. Neutral Citation No. [2013] NIQB 15, Ref GIL8732, Delivered 22/01/2013. Concerns the circumstances in which a court may refuse to admit hearsay evidence (which, from INQ000253 appears to apply to [016]1). It also includes reference to the attribution of one of the phones (980). This ruling does not appear to be directly relevant to the technical matters considered in this report.
- v) 2013. INQ013576. Neutral Citation No. [2013] NIQA 75, Ref GIR9074, Delivered 19/12/2013. Similar matters are discussed as in INQ000253, in particular surrounding provenance, reliability and admissibility of call data. There is a summary of phone usage, including comment on the reliability of call data, provenance of specific phones and general areas of usage. Eircell records are available for phone 585. Cell Site Analysis was also conducted on the Banbridge bombing of 01/08/1998 and the Lisburn bombing of 30/04/1998.
- vi) 2017. R v Calland [2017] EWCA Crim 2308 ["references" 1.30] was a prosecution appeal against a trial judge's decision to exclude Cell Site Analysis evidence which the prosecution had sought to adduce from a Police Analyst. The Defence had objected to the prosecution relying on non-expert evidence to invite the jury to believe that a call made by a mobile phone in a particular location must be routed through a specific phone mast located nearby. They argued that the Prosecution had *"unhelpfully conflated the location of a particular mast with the question of what safe inferences can be drawn about the location of a telephone using it"*; these arguments were upheld. These concerns, while not expressed within a legal context, would still be valid for non-expert analyses in 1997-1998. The concern raised is that a superficial examination of mast locations has been conducted rather than a more considered view of the service areas of the cells used, resulting in the illusion of precision and potentially misleading probative value of findings. The analyses that I have reviewed for the Omagh Bombing contain expert assessments of service areas with clear caveats on the limitations on usage of the results. In my view, the concerns raised in this ruling do not apply to the work undertaken during the Omagh investigation that I have reviewed as the analysis was presented as expert evidence and has specifically not *"conflated the location of a particular mast with the question of what safe inferences can be drawn about the location of a telephone using it"*.

INQ042496

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7.13. Telecommunication regulation:

7.13.1. Ofcom. Ofcom was formed in 2003. Prior to 2003, the Radiocommunications Authority (RA) was responsible for telecommunication regulation in the UK. Ofcom regulation includes spectrum licensing ["references" 1.31]. **INQ042493**

7.13.2. In 2000 the (RA) were asked to set up the web-based "Sitefinder" database detailing the locations of externally sited base stations in the UK. I have a copy of the database which was downloaded in 2012 after I joined my current employer (CCL Forensics). This data was not collected in 1997-1998 (INQ011781 paragraph 4.5), but has been useful to me in cross referencing the data received concerning cell sites to verify their locations and indicate the extent of later change (i.e. implementation of new sites or removal of old ones). The use of Sitefinder within analyses is primarily to provide general context as to cell site density; the more cell sites in a given area, the smaller the expected cell sizes of them. The cell site detail used in casework is provided by the network provider along with the Call Data Records on a case specific basis.

7.14. Network Operators. I understand that in 1997-1998 Physical Network Operators included:

7.14.1. United Kingdom of Great Britain and Northern Ireland (INQ011781 section 3.5, Ofcom)

- i) Vodafone. It is apparent from that the period 1997-1998 was a time of great change, with the rapid implementation of a (digital) GSM network replacing the pre-existing analogue TACS network. The scale of change is described in INQ000740 & INQ000741.
- ii) Cellnet (later becoming BT Cellnet in 1999 and then O2 in 2002 as described in INQ000718).
- iii) Mercury One2One (described in INQ015714). One2One became T-Mobile in 2002 and, after merging with Orange, became EE in 2012.
- iv) Orange (described in **INQ028453**) in 2012 merging with T-Mobile becoming EE.

7.14.2. Republic of Ireland

- i) Eircel - (described in **INQ028453**) and now Vodafone Ireland as in INQ012962).
- ii) ESAT Digitone - (described in INQ000718).
- iii) Meteor (described in **INQ028453**)

The "3" Network Operator wasn't launched in the UK until 2003. There were no Mobile Virtual Network Operators in 1997-1998 (MVNOs - mobile phone service providers who utilise another company's physical network, such as Lyca, Lebara or Tesco Mobile do now); the first was Virgin Mobile in 1999. That said, many companies, including phone manufacturers like Motorola, NEC, Panasonic, and Sony, had divisions that resold airtime from BT Cellnet and Vodafone to promote their device sales. These were often sold directly to businesses. This

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means that some manufacturers essentially locked their handsets to a specific network (which would have the same effect as if they were selling directly from that network such as we see today, e.g. a phone bought from Vodafone is locked to only using the Vodafone network).

- 7.15. **Technology used by networks.** TACS (1G) and GSM (2G) physical digital networks were available in 1997-1998 [“references” 1.31]. GSM was established but still in the process of being fully implemented.

7.15.1. TACS (Total Access Communication System) was an analogue system first introduced in 1983. On **Page 21 of INQ028453** (a review of the Cell Site Analysis for the Omagh Bombing Praesidium Services Ltd.) *“Total Access Communications System (TACS) is an analogue system while the latest systems are digital and comply with the GSM standard. There are distinct technical differences between the two systems but **the phones considered in this case are specifically digital.** Reference will therefore not be made to analogue systems.”*. The words in bold are my emphasis. TACS is therefore not specifically relevant to the material considered in this report. For general information:

- i) TACS is designed for analogue voice use only (INQ011781 paragraph 3.8) and cannot roam (i.e. move between the Republic of Ireland and Northern Ireland, as described in INQ000718 paragraph 15). Data was far less useful for forensic purposes than digital networks and it had “weak security features” (INQ000718 paragraph 14).
- ii) Vodafone and Eircell discontinued TACS in 2001, having phased it out in favour of GSM over the previous years. Vodafone were rapidly transitioning between TACS and GSM in 1997 and 1998, as described in INQ000740 & INQ000741.
- iii) Cellnet were using both TACS and GSM according to Andrea Murray in section 13 of INQ000718. Paul Griffiths states that Cellnet was using TACS in 1997 and 1998, as described by in sections 6 & 13 of INQ013044.

7.15.2. GSM (2G) is a digital network still in use at the time of this report. GSM was the technology on which all of the phones under consideration in the reports considered for the Omagh Bombing were using. It supports voice calls, text messages and data connections (although “web type” services were not fully implemented in 1997-1998). Licenses were first issued in 1991.

- i) Vodafone were rapidly implementing GSM in 1997 and 1998 as described in INQ000740 & INQ000741.
- ii) Cellnet were using GSM as outlined in **INQ000718** & INQ000719, which include roaming agreements between ESAT Digifone and Cellnet from 03/03/1997.

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- iii) UMTS (3G) licenses were yet to be issued (2000) and are therefore not relevant to this report.
- iv) LTE (4G) licenses were yet to be issued (2013) and are therefore not relevant to this report.

7.16. **Communication types.** The manner in which mobile phones are used has changed since 1997-1998.

7.16.1. Voice calls were the prime focus of mobile phone usage in 1998.

7.16.2. Text messages (Short Message Service, SMS) were less prevalent than they are now. Initially text messages could only be sent to subscribers on the same network; this restriction was lifted in 1999. I do not know how this limitation would affect a phone that was roaming, although I note that SMS messages were present in [O16]1 (INQ000433), for example in the data for phone 5430 there is a text message with a listed time of 14:30:33. Contact via SMS was possible on the GSM network but TACS did not support text messaging. There were voice calls as well as text messages in the data that I have considered. An example of a text message is in the call data for 086[PD]5430 in [O16]1 (INQ000433) along with the details of voice calls in a similar period.

7.16.3. While GPRS connections were introduced as part of the GSM standard in 2000, I understand that the now-obsolete WAP (Wireless Application Protocol) was developed by June 1998. Wireless Application Protocol (WAP) was a set of communication protocols designed to enable mobile devices to access the internet. It was specifically created for devices with limited processing power and small screens, such as early mobile phones but was slow and had limited access to the internet. "Web-type" services were new and not fully established in 1998 ["references" 1.31]. WAP ceased to be relevant once 3G (and later 4G) smartphones were introduced from the late 2000s. There were no "data" connections in the call data considered.

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8. Call Data (Toll Tickets); Content

Explanation of the data that Telecommunications Service Providers obtained and retained in 1997-1998

- 8.1. In current (2025) CDRs, when a call is made or received, the network usually records the Cell site (and Cell ID) along with other information such as the type of activity (e.g. call or text), the duration, date, time and the number with which it was in contact. The location of the cell site and azimuth (the direction in which a given Cell ID was pointed) of the cell used is also recorded. These data are amalgamated from different parts of the network (the MSC, a location database showing cell site locations and details etc.) using an automated method and presented in electronic format - usually as comma separated variable files but also as .pdf documents. While the specific format of Call Data varies between networks, there is consistency in the primary types of information required for cell site analysis. My earliest involvement in cell site analysis was in approximately 2003 and CDRs routinely contained these fields by this time (with the exception of T-Mobile which only presented the postcode of the site and for which a specific request had to be made for azimuth information) and were generated by automated processes.
- 8.2. According to the files that I have reviewed, in 1997-1998 CDRs did not exist as they do now. Call data with cell site information were presented as "Toll Tickets". [O16]1 (INQ000433) is an example of such a Toll Ticket from the Vodafone network in Northern Ireland. [O16]1 was collated (sections 61 to 65 of INQ000253) rather than generated by automated processes as has been the case for the last couple of decades or so. The principles of the Toll Ticket are the same as that for a contemporaneous CDR, namely that they are intended for use in billing, but might be repurposed for forensic use.
- 8.3. [O16]1 is described on page 3 of INQ012962 (a cell site analysis report by Peter Bristowe) as being roaming data for phones originating on the "Eircell" network using the Vodafone network in Northern Ireland. Within [O16]1 (INQ000433):
- 8.3.1. For "incoming calls received from the network" the information in the headers included:
- i) Date
 - ii) Time
 - iii) Number Dialed
 - iv) Duration
 - v) Base Site (which in actuality appears to be the Cell ID)
 - vi) Location
 - vii) Date
 - viii) Time
 - ix) Caller

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- x) Duration
- xi) Base Site (which in actuality appears to be the Cell ID)
- xii) Location of Caller

8.3.2. The "location" is an address, rather than co-ordinates as are provided in current formats. Additional information is available, but appears to have been the result of case-specific enquiries. Such detail is provided on pages 9 and 10 of INQ029156
and INQ029157 and includes:

- i) Site (which I understand to be the Site ID)
- ii) Cell (which I understand to be the sector, as discussed below)
- iii) Cell Name (which when combined with the sector I understand to be the Cell ID)
- iv) X (which I understand to be the British National Grid Easting, as discussed below)
- v) Y (which I understand to be the British National Grid Northing, as discussed below)
- vi) Status (all marked "In-Service")
- vii) Type (all marked "G", which I assume means "GSM")

Also available for some cells (but not provided for all) were:

- viii) Height
- ix) "SV" as either "DIR" or "OM". I do not know for sure what these acronyms represent but believe they may be "directional" (for a sectorised site) and "Omni-directional" (for a site that is not sectorised).

I do not know why this data was available for some cells and not others; I assume that it was to do with specific requests for information to the network.

8.3.3. There is no explanation of the headers provided. My current understanding is for:

- i) "x" and "y" are co-ordinates in British National Grid (BNG) format. To confirm my understanding I have plotted the co-ordinates provided in and
 - a) compared them to the address provided in the Ticket Toll.
 - b) compared the co-ordinates of the sites against those in the Sitefinder data from 2012.

I have no reason to believe that the locations provided are inaccurate.

- ii) "Cell" indicates the sector. As a general expectation on Vodafone, I understand that a value of:

- 0 indicates it is an omni-cell (an antenna which transmits equally in all directions i.e. 360 degrees rather than sectorised)
- 1 indicates sector 1, usually facing eastward (often, but not always, 90°)
- 2 indicates sector 2, usually facing southwest (often, but not always, 210°)
- 3 indicates sector 3, usually facing northwest (often, but not always, 330°)

Only values of 0, 1, 2 or 3 are in the data provided.

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- iii) The "Cell Name" is the "Site" with the "Cell" added on the end, and I would normally call this a "Cell ID". For example, there was a cell site in the records at McCauslands Car Hire (at 171 Airport Road, Aldergrove Airport). Two sectors of this site were used by phone 353 87[PD]6132 (Jon Fee); 58643 at 09:00:45 and 58642 at 09:40:2. The co-ordinates of Site 5864 is not one of those sites defined in [INQ029156 and INQ029157] but is in the Sitefinder data I have considered, and I have confirmed that the co-ordinates in that dataset are on Airport Road. The Site ID/ Sector definition of a Cell ID is described in the report of Peter Bristowe, for example in point 29 (page 5).
- 8.3.4. These records are not as user-friendly as contemporaneous formats of call data and do not contain all of the information useful to Cell Site Analysis. I understand, from page 43 of INQ011952 (a cell site analysis report from Peter Brown in 2008) and page 20 of the Breslin ruling (INQ000253) that the data was an excel file prepared by an unspecified individual from unspecified source data. The reliability of this Toll Ticket was a matter of dispute between Mr Brown and Mr Bristowe that was discussed in some detail in the Breslin ruling and is discussed in greater detail below (under "reliability" in section 9.9).
- 8.4. Additional information requests, for example that provided in [INQ029156 INQ029157] which provides co-ordinates of some cell sites, are useful when using the information in the toll ticket for forensic purposes. That said, an address is provided in the original Toll Ticket and that could be used if no additional information was forthcoming.
- 8.4.1. Information I would normally expect to be held and available would be azimuth and, potentially, mast height and beamwidth of the antenna used. There is no azimuth listed in any of the information I have considered, even in the more detailed cell data contained on pages 9 and 10 of [INQ029157 INQ029156]. This surprised me, given that coverage prediction plots were also included in that document, which would rely on azimuth information for them to have been produced.
- 8.4.2. The only mention I have found of azimuths anywhere in the material I have reviewed is in INQ012962, a "Cell Site Analysis Report" by Peter Bristowe (Ref FFT/0708/073/DB). On page 6 (point 36), he states that he believes that Cell ID 61451 ("Pigeon Top") has an azimuth of 70 degrees "from previous work".
- 8.4.3. Collectively, this leads me to believe that:
- a) Azimuth information wasn't provided as part of the standard "toll ticket" not just for Vodafone, but for all networks considered.
 - b) Azimuth information wasn't provided even when additional cell details were requested.

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8.5. Within the "Cell Site Analysis Report" by Peter Bristowe (page 3 of INQ012962), a range of call information is specified:

- i) [O16]1; Vodafone Toll Ticket Analysis (INQ000433, considered in detail).
- ii) Coverage Maps for Vodafone Cell IDs 61451 & 46852 (INQ034428 & INQ034430).
- iii) PG1, Cellnet cell site locations (Not found in submitted material).
- iv) Billing data from Eircell (I have assumed this is in INQ001614 & INQ001615).
- v) Cell Site Data from O2 (Digifone) (I have assumed this is in INQ012782, INQ012796 and INQ012797).
- vi) Appendices 1,2, and 6; call data from Vodafone Ireland (Eircell) (Not found in submitted material).

Mr Bristowe does not discuss network-specific limitations, and I have no reason to believe that the limitations of the data for the non-Vodafone networks are not similar to those already considered in [O16]1. For example, the absence of azimuth information and the necessity of requesting additional information for specific cells of interest appears to also apply to BT Cellnet and Eircell records.

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9. Call Data (Toll Tickets); Accuracy.

Examples of uncertainties of which I have encountered within Call Data over the last twenty years include, but are not restricted to:

- 9.1. "Other Party" Call Data. Even though a data request is focussed on a specific phone, other user's cell site information can be included in some formats. I have encountered such uncertainties from the beginning of my involvement in Cell Site Analysis, and still encounter it in raw data (we automatically remove it as part of normalising the call data, now usually performed by automated tools) at the time of writing this report. For example, on the Vodafone network, if there is a voice call involving the target phone (i.e. the phone for which the call data is requested) and the other party is also on Vodafone, the other party data can be included in the call data for the target phone. This can be detected (and therefore excluded from the analysis), but obviously the practitioner needs to be aware of its existence to handle the data appropriately. Examples of "other party" data were observed in INQ000433 and are discussed in more detail below. "Other party" data did not form any part of the evidence that I have seen (and as such, while this is a "general hazard" in my view there is nothing to indicate that hazard was realised in the analyses I have reviewed).
- 9.2. The location for a cell site (postcode, latitude/ longitude or British National Grid values) or listed azimuth can be incorrect. I have encountered such uncertainties from the beginning of my involvement in Cell Site Analysis, and still encounter it at the time of writing this report. This is known to happen but extremely unlikely in my experience (i.e. it is always a possibility, but very improbable for any specific record being considered). For call events that form critical findings in a contemporaneous examination, survey data would normally be gathered and this can detect this type of error. Addresses were provided in the Toll Ticket provided, and additional data received including co-ordinates for many of the listed sites. In my view there is no indication that any of this information was incorrect in the data I have considered.
- 9.3. The name of a cell site can be misleading or not unique. I have encountered such uncertainties from the beginning of my involvement in Cell Site Analysis, and still encounter it in call data at the time of writing this report. In my view there is no indication that this occurred in the data I have considered (i.e. I have been able to cross-compare co-ordinates with addresses, and they correlate, as outlined elsewhere in this report).
- 9.4. Timings of incoming text messages can sometimes be from other parts of the transfer process for some networks (e.g. when received by the network rather than transferred to the target device). I have encountered such uncertainties from the beginning of my involvement in Cell Site Analysis, and still encounter it in raw data (we do not use the "wrong" time as part of processes to normalise the call data, now usually performed by automated tools) at the time of writing this

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report. There is only one text message listed in the Toll Ticket examined and this did not include cell information. As such, this is not a concern in the data received.

- 9.5. Errors can also take place in the normalisation process. For example, between 2010 and 2019 Call Data used in the Danish Criminal Justice system was flawed ["references" 1.34]. Many of the issues were to do with the automatic processes used to collate and normalise the data. For "Toll Tickets", the data requires manual processing and in my view it is unlikely that the errors encountered by the Danish would apply; the data was independently reviewed in detail by a number of experts instructed by both Prosecution and Defence and indeed myself. If there were errors in normalisation, we would all have had to make them independently, which seems extremely unlikely. I do not believe this to be a reasonable concern.
- 9.6. Beyond uncertainties in the specific technical fields that constitute a given record and the manner in which that data is normalised, the validity of the source data itself was discussed at length in the ruling in INQ000253 (including but not restricted to paragraphs 37, 38, 46, 55, 61, 63, 65 and 66). For those numbers on which I have conducted analysis, the call events were agreed as valid by experts appointed independently by both Prosecution and Defence (paragraph 56). The Judge summed up his position clearly on this matter in paragraph 65 *"The possibility of human error has to be recognised and indeed one example of it was discovered in relation to one of the entries but it is common case that there is a high level of competence within Vodafone... There was no motive to conceal or misrepresent matters and the only editing of the information was designed to make it relevant and manageable. There are in my view no circumstances to suggest any attempt to prevent proper evaluation of the weight of this evidence."* In my view, while practice throughout my career has been to keep a gold copy of the call data in its original form (as Mr Brown described in paragraph 5 of INQ011952) and this is a requirement within the FSR Code. Even CDRs are not the earliest form of raw data; I have never had access to the data which forms any CDR to check if the CDR itself is a fair representation of all data and neither do I believe I have ever needed to. I have performed many "blind trials" from CDRs where an individual makes calls, the CDRs are requested and I have performed my analysis without knowledge of the "true" outcome. This tests the entirety of the process, from the veracity of the traces considered, to the validity of the methods used to analyse them, to my competence in performing the assessment. The outcomes have always been positive (i.e. I always got the right answer when the right answer was known) which implies that the entirety of the process is legitimate – or at least that it is not demonstrably not illegitimate. My point is that there is a limit to how far back in the formation of the data considered that any expert can go, and always has been. There were no defined processes of which I am aware in 1997-1998, so failure to comply with procedures at a later date does not seem a legitimate criticism. I accept that it is possible

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that transcription errors may occur (and indeed did) in the production of [O16]1 but this is in itself is not in my view a reason to discount the validity of the entirety of the record unless there is evidence of systemic failure or selection bias. From my reviews, I have found no evidence to suggest either.

- 9.6.1. Page 12 of INQ000718 highlights that non-billable information (potentially incoming and unanswered calls) would be lost once data was transferred to billing which could be (from page 18 of INQ013044) between a few hours and a few days. In the absence of an established process there is an obvious tendency for information that would be included (and useful) in current processes to have been absent in 1997-1998. I do not view these as errors of omission, more "potentially missed opportunities". I have no reason to believe that these processes were not replicated on other networks, and this may provide a possible explanation for the manner in which [O16]1 was produced (i.e. via a range of time-sensitive data sources).
- 9.6.2. I am aware that an ex-colleague (Brian Edwards) was actively involved with testing the veracity of Call Data in the late nineties, generating data for the Radiocommunications Agency (later Ofcom). The testing was primarily focussed on call time and duration as these were the prime basis of billing and were intended as an independent check that billing was accurate. While I am not aware of the results of this testing, I do know that the veracity of content of Call Data was a focus of external quantitative testing which again lends confidence - but not perfect assurance - to the reliability of the data considered.
- 9.7. [INQ028453] is a "Description of GSM problems and issues in relation to Telephone Billing", issued by Praesidium Services Ltd. This document provides a comprehensive description of the limitations of using call data. Of particular note are:
- 9.7.1. Page 13. Information can be incomplete (i.e. errors of omission). Some call events are not retained (i.e. are lost), but information recorded is usually accurate (it is not clear what testing took place to make this assessment).
- 9.7.2. Page 14. Timing of call events can be inaccurate "up to several minutes".
- 9.7.3. Page 14. Cells serve areas, and these areas are dependent on a range of factors including terrain, power, "clutter" (e.g. buildings, trees), antenna type. Congestion may affect which cell is selected.
- 9.7.4. Page 15. Prediction plots are just that, predictions. They are theoretical expectations that cannot be guaranteed to be "true". Predictions for specific cells were informed by measurements within the investigation (INQ013302 & INQ013303). I agree that these concerns are valid and that the limitations of the analysis were apparent to those using the results from it.

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- 9.8. **INQ028453** is a review of "the use of mobile telephones & the associated Call Records and Geographic Information", issued by Praesidium Services Ltd. Of particular note are:
- 9.8.1. Page 7. There are no fixed boundaries to coverage areas of any cell.
 - 9.8.2. Page 8. Networks are designed such that a number of cells can usually provide service at a given location, and the nearest cell site is therefore not necessarily the one that is used.
 - 9.8.3. Page 8. Errors in CDRs can happen. For example erroneous call type classification, Cell ID, billing tariff and duplicate calls being logged.
 - 9.8.4. I agree that these concerns are valid and that limitations of the analysis were apparent to those using the results from it.
- 9.9. I acknowledge that there may have been additional issues of which I am unaware in call data in 1997-1998 which are different to those I have encountered since 2003. That said, any such uncertainties would also be unknown to Dr Brodie (who checked this report), Praesidium and everyone else who contributed to the documents I have reviewed including, but not necessarily restricted to, Mr Uglow, Mr Bristowe, Mr Brown and Mr Weeks. We are from different backgrounds and therefore our understanding of processes is largely independent of one another. This does not provide perfect assurance that there were no additional uncertainties, but in my view is an indicator that this is a low risk consideration.
- 9.10. Other Party Call Data.
- 9.10.1. I have previously mentioned "other party" data above. The "other party" data I discuss was not used in any of the analyses I have reviewed and I do not believe that this hazard was realised. I go into some detail here to emphasise that misleading information can be (and indeed is) included in call data (both in 1997-1998 and contemporaneously) and that such information was (correctly) excluded. This provides greater confidence in the analyses conducted.
- 9.10.2. Within the data contained in INQ000433 (**Q16**1) there is evidence that suggests that cell information of incoming call data may not be that of the target phone. Please refer to "Map_Uncertainties; Example of "Other Party" call data" in exhibit MST/Cell_Site_Analysis_Explanation/241025. I have illustrated an apparently impossible call sequence from the Toll Ticket for phone 353 86**PD**5430 (Oliver Traynor). Within the call data, phone 5430 appears to receive incoming voice calls using, at:
- i) 14:10, a cell based at Pigeon Top (Cell ID 61451) near Omagh.
 - ii) 14:24 and 14:25, a cell based at the British Rail Station Car Park, Holyhead (Cell ID 45760) in north Wales. The Holyhead cell site is based approximately 230km southeast of the Pigeon Top cell site, which was listed as being used 14 minutes earlier.

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- iii) 14:38, a cell based at Cranlome (Cell ID 4620). The Cranlome cell site is based approximately 205km northwest of the Holyhead cell site, which was listed as being used 13 minutes earlier.

9.10.3. A normally operating GSM cell has a maximum range of 35km. Taken at face value, assuming that each of these cells provided service 35km from the mast and the phone connected at the last possible instant, this would require a minimum average speed of over 700km/h. As a deductive inference, this is not a reasonable explanation for the data. As previously noted, "other party" call data can be included in raw data and is even in currently encountered records if both phones are on the same network. I have compared the Toll Ticket data for those phones with which phone 5430 was in contact for these call events. At:

- i) 14:10, the Toll Ticket for phone 5585 (with which 5430 was in contact) also listed the same cell based at Pigeon Top (Cell ID 61451) near Omagh.
- ii) 14:24 and 14:25, I do not have the "other party" call data and cannot make an assessment.
- iii) 14:38, the Toll Ticket for phone 5585 (with which 5430 was in contact) also listed the same cell based at Cranlome (Cell ID 4620).

A more plausible explanation for the data is that Cells listed within some incoming records originated from the outgoing records of the phone with which the target phone was in contact. I do not have the call records for the other phone to test this proposed mechanism for this specific instance, but have done so in analyses from 2003 and so believe that "other party" data is a reasonable explanation for the call sequence.

9.10.4. Please refer to "Call_Sequence_Table; Data from Toll Tickets received", call 9.

- i) At 13:57:53, phone 3980 receives an incoming call lasting 28 seconds, with "incoming call" being listed as the originating number. The cell listed for phone 3980 is 61451 (Pigeon Top).
- ii) At 13:57:53, phone 5585 makes an outgoing call. This is apparently the same call, as phone 3980 is indicated as the number called and the duration is the same. The cell listed for 5585 is 46852 (Omagh College).
- iii) At 13:57:54, there is a separate record of phone 3980 receiving an incoming call lasting 28 seconds "incoming call" from 5585. The cell listed for 3980 is different to that listed a second earlier; it is now Cell ID 46852 (Omagh College) - the same as that for phone 5585.

The two records for phone 3980 appear to be for the same 28 second call, but two Cell IDs are listed within one second of each other. It is normal in current CDRs for voice call records to have one cell listed for the beginning of the call and another at the end, but

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these events are both within a second of the beginning. My current understanding is that phone 3980 used Cell ID 61451 to receive the call when it connected, and then there was then an additional record included in the Toll Ticket for phone 3980 that actually originated from phone 5585 (which was also using the Vodafone network for the call).

- 9.10.5. The "other party" data may contain more detail than the originating phone. For example, at 14:14 3980 called 4259 (call 12). The Cell ID listed for the outgoing record is 6145 which is the Site ID for Pigeon Top but does not include the sector. The incoming record within the data for 4259 (which I believe may be "other party" data) includes the sector, and so gives a Cell ID of 61451.
- 9.10.6. I have encountered "other party call data" throughout my time working on telecommunications data and it exists in some formats of CDR from Vodafone even today. It also exists in other networks, for example in CDRs for "3" and also (the legacy network) Orange. Consideration of other party call data is covered in a paper published in "Science and Justice" ["references" 1.16] which also describes the processes used to detect it (and which I used in this examination). Correct identification/ exclusion of other party call data is amongst the acceptance criteria that CCL use when validating CDR normalisation tools. When "other party" call data is present in a CDR there are usually two lines of data, one from the originator and one from the receiver. In [016]1, there is only one line and a "match" between cells used by originator/ receiver is inconsistent. The "other party" call data was (correctly) excluded in the analyses I have reviewed.
- 9.10.7. Within the cell site analysis report INQ012962, Peter Bristowe states (paragraph 19) that [016]1 (INQ000433) contains roaming data on Vodafone. He goes on to state (paragraph 31) that phone 5430 was using the O2 (Ireland) Digifone network on 15/08/1998; [016]1 has "roaming" call activity concerning it on the Vodafone network in Northern Ireland. He discusses usage of specific O2 cells. For example, he states that O2 Cell ID 24043 based in Clermont Carn to the east of Dundalk in the Republic of Ireland was used at 14:10 (with the Cell ID in [016]1 discussed above as being 61451 on Pigeon Top). I have not received the Republic of Ireland O2 data upon which Mr Bristowe has relied but, for the purposes of testing the "other party data" theory, do not have any reason to doubt his finding. This provides apparent confirmation of the "Other Party" call data explanation proposed above.
- 9.10.8. As a rule of thumb, my current view is therefore that if there is an incoming call event and the "caller number" field of the Toll Ticket is:
- i) "incoming call", the Cell ID may be trusted as being used by the target number.

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- ii) If a number is given, the Cell information may be from the calling number's records (and not the target number receiving the call).

9.10.9. If the target phone was not using the Vodafone network, there may still be Toll Tickets generated by Vodafone concerning it if it was in contact with numbers which were on the Vodafone network. If this were the case, for the target phone:

- i) There would be no outgoing calls in the (Vodafone) Toll Ticket.
- ii) Any cell information provided would be for the number calling it.

9.10.10. My overarching view of this "other party" call data is that:

- i) From the reports I have reviewed the "other party" call events were (correctly) excluded and I have no reason to doubt the analysis conducted.
- ii) The Call Data considered contains potentially misleading data, requiring consideration in detail by practitioners with a deep understanding not only of network operation and anticipated cell service areas, but of uncertainties in the traces considered (i.e. the Toll Tickets).
- iii) Cell Site Analysis was a new technique (potentially novel for those engaged in it in 1997-1998) at the limits of capability, and should be viewed as developmental rather than established. As a result, analyses would be time consuming, with lower precision and there would be fewer practitioners capable of conducting the analysis than for a current-day examination.

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10. Call Data (Toll Tickets); Access.

I do not (and never have) requested data directly from networks for use in casework as part of my role. I am a user of the call data requested by others and if I wish additional information would do so via those instructing me. My general understanding is as follows:

- 10.1. I do not know details of rules or regulations covering access to Telecommunications data prior to 2000.
- 10.2. The Data Protection Act (DPA) is listed as the mechanism by which data was requested. For example, INQ011612 describes the process used by Vodafone as "*Section 28 of the Data Protection Act 1998 which exempted personal data for reasons of national security or 29 the Data Protection Act 1998 which allowed a disclosure for the purposes of 'the prevention or detection of crime [and] ...the apprehension or prosecution of offenders' under s.29(1).*". This was also the mechanism used by BT Cellnet described by Mr Griffiths as documented in section 24 of INQ000718.
- 10.3. INQ013109 is a briefing note from the ACPO Telecommunications Industry/ LEA Focus group detailing a meeting that took place on 25/06/1997. There is resume of a discussion concerning a central point of contact for requests which was viewed as "not a viable proposition". A two tier approach is suggested. "*What has been put forward from the Police side, however, is a two tier model whereby a limited number of specific central points of contact could be established within the UK to cater essentially for sensitive services the telecommunications industry can provide at the present and in the future, such as developments in cell-site analysis*". This appears to indicate that, in June 1997:
 - i) There was no formal structure for access to telecommunications data in place.
 - ii) The requirement for such a structure had been identified, but not yet acted on.

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11. Call Data (Toll Tickets); Retention.

I do not (and never have) requested data directly from networks for use in casework as part of my role. I am a user of the call data requested by others and if I wish additional information would do so via those instructing me. My general understanding is as follows:

- 11.1. The Regulation of Investigatory Powers Act, covering the powers of public bodies to carry out investigations including telecommunications data was introduced in 2000. I have only ever conducted work in Cell Site Analysis when this Act was in place. I understand that UK Telecomm Operators (TOs) are currently required to retain data for 12 months; on occasion subscriber data can go a little further back as Telecommunication Operators may retain it for business purposes.
- 11.2. INQ000718 (dated November 2024) could not locate retention policies from 1998 and states that O2 (or "Telefonica UK" as they are otherwise known) retains "call records" for 12 months (point 19 on page 7), "billing" data for seven years (point 20) and requests from Law Enforcement Agencies (LEAs) for two years (point 25). Vodafone could also not locate retention policies from 1998 (page 3 of INQ011618) when asked in 2025; Raymond Green of Vodafone believed they were held for between 6 to 12 months (paragraph 38 of INQ000257). Peter Brown also recalls that CDRs were held for 365 days (page 5 INQ013721).
- 11.3. Personal initiative was used to preserve at least some of the data after the Omagh Bombing in 1998. Within INQ000718 point 33.1, it notes that Paul Griffiths proactively saved data related to the Omagh bombing in anticipation of a request from Law Enforcement, which implies that no guidance was formally in place within the network employing him and, by extension, at a wider level (i.e. regulatory or legislative) at least for the types of data he was preserving. This implication is supported by the discussion concerning request and disclosure of call data on page 12 of **INQ013044** which is described as being via "*informal agreements between the telecoms industry... and ACPO*". In my view it is reasonable that data retention for data with cell site information (as opposed to billing which may contain details of contacts but no location data) may also have been via informal arrangement. It is not clear whether the Toll Tickets would have been lost without Mr Griffiths initiative.
- 11.4. Some data useful to cell site analysis may have been stripped out within days. For example, page 16 of INQ013044 states that cell site information for 1G networks was lost when data was transferred to billing (which was within days of the calls) and non-chargeable call events (e.g. incoming calls) would also be lost once data was transferred to billing (page 12 of INQ013044). Cell site information is not relevant to charging and may have been amongst that lost.
- 11.5. Within the material considered I have found no evidence that there were formal processes in place for retaining call data with cell site information in 1998. Without a formal process, there is a risk that data could be lost (which is a reason for a process being made formal).

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12. Capabilities of Cell Site Analysis in 1998

- 12.1. By 1998, use of call data in investigations was "not usual practice" (page 24 of INQ013044) and was treated as a "sensitive" method (page 13 of INQ013044). There were no formal arrangements for the request, retention or transfer of call data to investigating authorities in place (page 12 of INQ013044). I am only aware of the following cases that used Cell Site Analysis before the Omagh bombing.

1992; Manchester Bombing; Not presented at court

- 12.2. Cell Site Analysis was used in response to the Manchester Bombing in December 1992 (referred to on page 10 of INQ013044) and this is the first reference to the discipline of which I am aware from any source, including experience beyond the material considered for the Omagh Bombing Inquiry. For the Manchester Bombing, tests were undertaken to see if the technique was feasible; there is no description of validation of methods or even the need to do so.

1995; R v Steele et al (Rettendon "Range Rover" murders); At court September 1997-January 1998

- 12.3. In INQ015549 (a statement of Detective Chief Inspector Louise Metcalfe on behalf of Essex Police, dated 26/08/2025) there is a summary of activity from the Essex Police Senior Investigating Officer (SIO). The statement includes detail of usage of call data from both 1G and 2G networks on pages 5 & 6. Cell Site Analysis is described from page 7, but appears to have been relatively crude as outlined in paragraph 55 *"This data would give you a triangular area on a map that is used by a mast and so identify what broad area the phone was when the call was made"*. This appears to be what would now be referred to as an "arc", flagging the azimuth and (usually) 60 degrees either side of it to indicate a broad direction from the mast in which, at a somewhat superficial level, the service area is thought to extend. The range of the cell cannot be reliably estimated in this way and it is usually used as part of an investigation as an initial indication or if a more detailed analysis is not required. Even this low-precision approach is described as a sensitive tactic "for intelligence purposes only" but ACPO could authorise evidential use, via instruction of private companies.
- 12.4. INQ015551 (page 2 "Box 2616") provides further information concerning usage of cell site analysis as part of evidential material in this murder. *"I have spoken to DCI Graham COLLINS (NCIS) re the cell site analysis evidence. There is somewhere a letter from Deputy Commissioner FRY to ACPO detailing the arguments for and against using cell site analysis in evidence. There is no formal agreement in existence. There is an acceptance that in circumstances where the cell site evidence is vital to secure a conviction in the most serious cases ACPO can authorise an approach the individual companies to request a statement re cell site analysis. All statements will*

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contain a caveat (sic) stating ta the evidence is not precise. The approach has been authorised by ACC "O" MARKHAM and contact should be made with the following persons for each company." Contact details for Orange, Cellnet, Vodaphone and Mercury One follow."

- 12.5. INQ027537 is an expert report from David Bristowe dated 30/08/1997 titled 'The use of mobile telephones'. The analysis appears to have been an examination for the defence. The analysis includes maps (both cell site locations and "service area" maps, which appear to be Best Server Prediction plots for both the Vodafone and Orange networks). It includes Toll Tickets and Call Detail Records. There are clear caveats on cells not having fixed boundaries, that cells overlap etc. and there is reliance on Best Server Prediction plots to predict where the phone was, but I did not find any reference to the azimuths of the listed cells. The report lists a range of material considered, including from the crown, survey results are not mentioned (although Mr Bristowe performed his own surveys as presented in INQ027520). There is no author background in this report.
- 12.6. INQ027520 is the "second supplementary" expert report from David Bristowe dated 04/11/1997 and titled "The Use of Mobile Telephones". Best server plots have been produced by Cellnet and used in the assessment. Measurements were taken by Mr Bristowe on the Cellnet analogue network (page 6). Two mutually exclusive competing propositions were considered (in my view this is good practice). There are appropriate caveats throughout the report, for example in 3.6. I do not have enough information to make confident comment on the survey equipment used (Mr Bristowe provides a number of caveats for his use of the "Alinco communications receiver") or the method in which it was used, although a single device, apparently static at the contested locations is prone to false negatives (not detecting all serving cells) in my view. It is clear from the report that Surveys were a capability before the end of 1997 even if all shortcomings weren't known (although some were listed). There is no reference to surveys made by the Crown, and I would expect there to be if such a method was relied upon. It is also not clear to me if surveys were used in criminal cases before the examination conducted by Mr Bristowe and, if they were, for how long they had been used.
- 12.7. INQ027524 is an expert report of David Bristowe prepared for the Court of Appeal, dated 11/01/2006 and titled 'The Use of a Mobile Telephone'. A background is presented on pages 2 and 3, amongst the detail of which are a degree in physics, working at Marconi and that he started giving evidence in 1993. He states that he had completed 160 cases by 2006, but it is not clear if these all involved cell site analysis or how many were completed in the earlier part of his career (including around 1998, when the Omagh bombing occurred). In section 2.3 he states that between 1993 and 1997 *"as far as mobile phone evidence was concerned, expert witness*

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service for the Prosecution were invariably provided by representatives of the mobile phone networks". He goes on to state that "However, it became apparent that although the representatives of the networks were prepared to introduce factual data... were unwilling to interpret the data or give expert opinion in Court".

- 12.8. INQ027532 sets out the Orange network's policy for use data, dated 03/04/1996. It states the requirement that application, correspondence and data be classified as sensitive. It also states that this position is not open for negotiation, and that if data is provided to the Defence, Orange will withdraw provision of further support. When used, the information was to be restricted to "need to know" and the information disposed of as confidential waste after use. It would only be provided in serious crime.
- 12.9. INQ027533 is a witness statement of Simon Collins, Head of Central Operations at Orange, dated 15/07/1996. Expert report. Simon Collins of Orange, explaining network operation, design and data formats. It includes call and cell site data (but no azimuth information, even though it discusses sectorisation).

1996; Manchester Bombing; Not presented at court

- 12.10. INQ038774 is a witness statement from Superintendent Benjamin Cottam of Counter Terrorism Policing North-West. It details a range of documents relating to call data for specific phones of relevance to the investigation. It mentions within the descriptions of INQ035841 and INQ035842 that cell site information was included in the information received from the networks. There is no detail included of how this location information was used.

1998; Moira Bombing; Not presented at court

- 12.11. INQ019752 is a Holmes record concerning a request for the "telephone liaison unit" to conduct cell site analysis." *As part of the Enquiry into the Bombing at Moira on 20 February 1998 I would request your Department carry out a Cell Analysis for that area between 2100 hours and 2330 hours on 20 February 1998."*

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- 12.12. INQ013112 discusses key issues for 1995/96. It includes a "...continued drive to raise the level of awareness within the Police Service of the technologies available and the associated threats and opportunities."
- 12.13. INQ013111 (dated 16/09/1996) discusses Orange advising that they will "no longer honour requests for subscriber information or itemised billing that do not emanate from the nominated

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direct points of contact within forces". This implies that the volume of requests received are requiring management.

12.14. INQ013110 (dated 03/04/1997) discusses concerns surrounding evidential use of cell site analysis, which is implied to be outside of formal control mechanisms:

- i) *"The aim of this letter is to raise Chief Officers' awareness to the original understanding, (dating back to pre-1995), between the Mobile Network Operators and the Police Service that Cell Site Analysis would be provided "for intelligence purposes only, and should not be adduced as evidence to be disclosed to the defence."*
- ii) *"The Resource Demands on Industry The Mobile Network Operators have limited staff to deal with requests for Cell Site Analysis. Their normal work involves providing a 24 hour engineering service to the system and as such they are vital to the day to day operation of the network. Whilst the Mobile Network Operators are quite prepared to offer Cell Site Analysis in support of serious crime investigations, they cannot sustain the staff losses caused by any subsequent lengthy Court attendance."*
- iii) *"Cell Site Analysis is not 100% Accurate The Industry is quick to point out that Cell Site Analysis is not a perfect science and, at best, is no more than corroborative. It can never be relied on as evidence that a person was at a precise location. It is no more than an intelligence tool."*
- iv) *"Public Knowledge of a Confidential Intelligence Technique The existence of Cell Site Analysis as an intelligence device, and its use by Law Enforcement Agencies, has recently received considerable coverage in the national press. This follows revelations at recent "high profile" cases. Such public knowledge has been enhanced by the recent tabling of a number of Parliamentary Questions. Continued exposure of Cell Site Analysis will undermine its usefulness."*
- v) *"...Additionally, we are in danger of being exposed to statutory control."*

N.B. For clarity, and in my opinion:

- a. Point iii) states that Cell Site Analysis is not 100% accurate in the context of a discussion surrounding evidential use. As cells serve areas I agree that cell site analysis does not precisely position a phone. This does not mean it is not useful evidentially; very few forensic science activities purport to perfect accuracy (i.e. categorical inclusions) and those that do are subject to intense academic debate.
- b. Point v); from context, the "we" refers to the police / ACPO and not the mobile operators.

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12.15. INQ013109 (dated 02/07/1997) contains a briefing. In July 1997, the need for formal arrangements were identified but had yet to be put in place. From the document:

- i) *"A degree of realism is now coming through from the industry that a central point of contact within UK policing is not a viable proposition. What has been put forward from the Police side, however, is a two tier model whereby a limited number of specific central points of contact could be established within the UK to cater essentially for sensitive services the telecommunications industry can provide at the present and in the future, such as developments in cell-site analysis".*
- ii) *"The industry predicts a substantial increase in service providers within the next five years without, it would appear, clear guidelines on regulations."*

Admissibility of computer generated evidence in criminal trials was covered by section 69 of PACE and was causing concern:

- iii) *"This issue is of particular concern to the industry in that the content of any such declaration is increasingly becoming potentially contentious in that the product of the intelligence/evidence may be routed through a number of differing systems not all covered in the present all-embracing Section 69 declaration."*

Requests for data were by 02/07/1997 of sufficient volume to cause concern. A recommendation was:

- iv) *"Continuing lobbying to ACPO that the critical demand placed on the Telecommunications Industry by the Police Service be reduced."*

It outlines a proposal for the Single Point of Contact (SPOC) system, later incorporated into standard practice.

12.16. INQ013127 (dated 17/02/1998) contains a notice of a move of premises by BT. It notes that for a period of time requests will be restricted to *"Terrorism, Safety Of Life, Kidnap, Attempted Murder, Hostage and Extortion, Paedophile, Dangerous Escaped Prisoners, Drugs-manufacture, importation, distribution, Sensitive investigations - Security, Government, Royalty"*. There is an obvious implication that by this point telecommunications data is in widespread use, at least during the investigation and that this restriction was viewed as an issue.

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Capabilities in 1998.

I outline below each stage required to conduct Cell Site Analysis as it appears to have been in 1998:

Submission

- 12.17. Initial Request. For at least one of the telecomm operators, the request was not made from the police to the network but was proactively raised by the network as a potential avenue for the investigation (page 13 of INQ000718). There is an obvious implication that cell site analysis was not a type of examination to be conducted by default.
- 12.18. Identification, request and receipt of required data; There are now established expectations of what data is, and is not, available which is controlled by the SPOC process. This was not so in 1998 in which arrangements for retention, request and delivery of data were via informal arrangement and not intended for court use. The production of call data with cell site information was described as the first time experience Paul Griffiths (who had helped set up and was leading the "network security team" liaising with Law Enforcement) and who collected raw network data rather than purely billing information that may have been otherwise lost (page 20 of INQ013044). Peter Brown stated concerns with source data in **O16**, which was a matter considered in detail in the Breslin ruling.
- 12.19. Generation and agreement of Forensic Strategy (identification of questions of probative value). The analysis appears to have been investigative, and then used for court. Competing propositions (i.e. assessment of whether the call data might be expected given the positions taken by prosecution and defence) on which the expert evidence should focus didn't take place; this is unsurprising as inference models were in their infancy in 1998 and had yet to be applied to telecommunications data.

Analysis - Normalisation of Call Data

- 12.20. Call Data from different networks are in different formats (e.g. the phrase used to denote an outgoing voice call varies). Call Data can also contain misleading information. For example, if Phone A and Phone B are both on the Orange network and phone A calls phone B, the cell information for phone B for that call will also be included in the Call Data for phone A in addition to that for phone A (the target phone); I have previously discussed this in section 8 of this report.
- 12.21. While the format for call data varies within and between networks over time, "rules" can be identified for normalising the records. This lends itself to automation and commercial tools are now available that automate this process. The tools can be validated, enabling greater confidence that the data considered (i.e. that the normalised version of the Call Data can be relied upon).

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- 12.22. Normalising call data would have been a manual process in 1998. The data would have been manually manipulated as part of the normalisation process rather than using automated processes which came later. This is the process I used when normalising the data from [O16]1 from INQ000433; I transcribed the records and amalgamated data from different sources using MS-Excel. Relevant data was not all provided in a single file or bundle as it is in current submissions. Given that data would have to be combined from different sources, a deeper level of understanding would be required to do this than currently the case. Error trapping (i.e. Quality control processes to ensure the normalised data is a true reflection of the source data) for manual normalisation is more difficult than for automated processes which reliably do the same thing repeatedly and can be validated as a separate exercise. In short, this process would be a more skilled task requiring greater technical understanding of the specific traces considered than is currently the case. Thus, even getting the data used for Cell Site Analysis was far more time consuming and complex (while it's later use is also far less precise). In my view this is a significant barrier for use of the method; it could not easily be used to conduct analyses involving trends, potential meetings or undertake attribution analysis using data from a long period as is routinely conducted today.
- 12.23. Understanding of issues with the quality of call data being recorded have steadily increased over time. I have considered documents specifically concerning uncertainties in relation to call data by Praesidium Services Ltd. ([INQ028453]). These documents contain a full and frank discussion of limitations of the traces analysed and methods used, and I broadly agree all of the matters raised and raise no additional risks; they are excellent documents in my view.

Analysis - Mapping.

- 12.24. Electronic mapping systems were available in 1998 and examples were in the submitted material, for example INQ000429 & INQ000431, which list both Vodafone and O2 cell sites, along with other geographic information such as the locations of Public Call Boxes (referred to as "PCB"s). These mapping systems do not appear to be substantively different to those in current use (i.e. I was able to reproduce the maps in INQ000429 & INQ000431 from the data received).

Analysis - Surveys

- 12.25. Cell service areas may change over time as sites are decommissioned or introduced, and there may have been a change between the time of the call and the survey. To mitigate for this, a current method would be to overlay "historical" data (potentially generated before the calls) with the "targeted" surveys (usually generated after the calls). This may enable an assessment of possible network changes, or whether additional cells may also have served at a given location

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at a previous time. Methods that I currently use are optimised to do this; surveys are conducted on most cases and have been for many years (we have data going back to 2010). Measurements from surveys my colleagues and I have conducted are collated into a system which now contains approximately a billion measurements. There is no evidence that such information was available in 1998, even if it existed.

12.26. Current Survey Technologies. Equipment currently employed for conducting surveys are:

12.26.1. Phone Emulators/ Engineering handsets; This survey tool is a handset with a SIM card in it showing serving cell information (and often neighbour cells, considered for service). Measurements can take place many times per second and have GPS co-ordinates attached to enable plotting via mapping software. This was the method used by Scott Southall (INQ013302 & 013303) and is discussed below.

12.26.2. Software Defined Radio, which is capable of simultaneously detecting cells on all networks, technologies and bands, highlighting which would be selected by a device. The measurements take place every few seconds and have GPS co-ordinates attached to enable plotting via mapping software. This method was not available in 1998.

12.26.3. Scanners. This survey tool is a radio receiver that shows details of carriers detected within a set frequency range. It does not emulate the algorithms that a mobile phone would use for cell selection. These are not commonly used due to issues with interpreting data from them but can be of use under specific circumstances (e.g. establishing whether a cell is off air and, if it was, if it can be excluded from serving at a location). Measurements can take place many times per second and have GPS co-ordinates attached to enable plotting via mapping software. I do not know if this method was available in 1998.

12.27. Surveys were conducted by a Vodafone Engineer (Mr Southall, described in INQ INQ013302 and INQ013303). The method used was a SIM based device connected to GPS, functionally equivalent to the Phone Emulators/ Engineering handsets discussed above. Mr Southall states that he *"also had a network trace (IMSI Trace) for the test mobile"*. I do not use that phrase when I use survey equipment. The IMSI is directly linked to the phone number of the SIM card. I therefore understand this to mean that, when calls were made, the survey equipment was being monitored by the network to record data gathered by the handset.

12.28. Upon network authentication, a GSM phone (such as those analysed for this Inquiry) continuously monitors signals of cells within range to determine the optimal connection as part of normal operation. While the handset selects the cell used to initiate the call, the system then enters 'Dedicated Mode'; here, the phone provides the network with real-time measurements of signal quality and strength for the serving cell and the signal strength for up to six 'neighbour'

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cells. This data is shared with the network so that the network (rather than the handset) can actively manage the call, executing handovers as a user moves between service areas or redistributing traffic to balance network capacity. Consequently, while the network does not track the phone's precise coordinates, it requires knowledge of the specific cells the device is utilising and monitoring while the call is in progress. I believe that the recording of this data, potentially along with additional "in call" information is what Mr Southall means when he uses the term "IMSI trace". Historical Call Data Records (CDRs) only log the cells used at the commencement and termination of a call; any intermediate handovers, candidate neighbour cells, or signal measurements are not preserved in these records.

- 12.29. I have only ever conducted Cell Site Analysis using "historical" CDRs and never performed live methods like an IMSI trace. I do not know if this data could be viewed by an operator in real time or if so the ease with which that would take place. An IMSI trace should not be mistaken for an "IMSI Catcher" which is a device for requesting the IMSI of each phone operating within range of the device so that they can be identified. Use of an IMSI Catcher" is also a "live" method that has never been part of my role, and I do not know when it was first used.
- 12.30. The purpose of the survey was to measure the maximum range of specific cells. The survey method was to use a single device and drive from the cell site of interest outwards in different directions while the equipment made calls. I have a number of observations concerning this method.
- 12.31. Driving from the cell site outward is a sensible approach when estimating the main body of service of a given cell. A handset will select a cell, and tend to hang on to it, only selecting a different cell if it has a stronger average signal strength for a period of time. There can also be offsets (known as "hysteresis") applied according to how the network is designed, for example on boundaries between Location Areas (cells that are clustered into groups for ease of network management). In my view this was sound practice for the type of assessment being conducted.
- 12.32. Mr Southall describes usage of measurements in paragraph 8 of INQ013302. *"The Special Survey Team was responsible for various roles and functions such as new cell site simulation, network measurement surveys (i.e. recording and capturing network performance), interference investigations and installation of temporary cell towers for high footfall events e.g. the British Open Golf. My duties as a Senior Engineer in that team involved assisting with all those roles and functions. The team had access to bespoke vehicles fitted with scanning receivers and GPS units to support these activities."* He goes on, in paragraphs 9 & 10, to state that *"A regional split was introduced in 1993, with one team continuing to be based in Newbury (the southern team) and one being established in Warrington (the northern team). To my knowledge, the only request*

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received by the northern Special Survey Team to support law enforcement/intelligence agencies was the Omagh bombing investigation. I am not aware of whether the southern Special Survey Team was involved in any such requests.". This appears to be unusual, possible "first use", of survey methods by the Vodafone team for Law Enforcement purposes in response to a large-scale investigation of a terrorist attack resulting in much loss of life. Within section 2.3 of INQ027524, Mr Bristowe believes that between 1993 and 1997 prosecution use of cell site analysis was "*invariably provided by representatives of the mobile phone networks*". If true, and the survey conducted by Mr Southall in 1998 was the first conducted for Law Enforcement by Vodafone it was apparently a very recent capability for investigative use (even if experts instructed by Defence were already using the technique).

- 12.33. The equipment was making calls. There is no currently established best practice for whether calls should be made or not; my personal preference is to do so as part of a wider strategy but for the bulk of measurements to be in "idle mode" (when the device is deciding which cell it would use if it was required to establish a connection without actually doing so). Making calls takes more time, resulting in lower density of data than if the device remained in idle mode and may result in a cell reselection while in call (e.g. due to network loading on the cell the device is connected to) which makes the data less relevant for "first cell" assessments.
- 12.34. A single device was used. Many cells usually provide service at a given location, but a phone will only select one at a given time and tends to hang on to it. A single survey device may be appropriate for engineering applications (e.g. monitoring metrics for a call setup), but for forensic use the tendency of a device to hold on to cells results in high "False negative" rates (i.e. other legitimately serving cells remain undetected resulting in underestimates of their service areas). That said, the number of cells serving at a location in 1998 was in my view likely to be far lower than would be the case in 2025 due to a far lower density of cell sites (as discussed in section 6.23) and fewer technologies/ bands being available. In short 2G was all that was available for a digital handset to choose from, and with wider spacing of cell sites other cells being considered would often be further away than they are now and thus have lower signal strengths.
- 12.35. Within INQ028453 the survey is described as having been conducted on 6/5/99 (which I have interpreted as 6th of May 1999). This is less than a year after the calls considered (August 1998), but was also in a period of rapid change. The measurements at the time of the survey may not have reflected the state of the network at the times of the calls.
- 12.36. The survey data was interpreted by the engineer in the context of other information e.g. mast height in the context of local terrain. I consider this to be sound practice that mitigates many

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limitations of using survey data. There was also comparison of survey results with that expected from the prediction tool output, as an independent two-way verification. In my view this lends confidence to the findings of cell coverage implied by the surveys, which of necessity cannot be undertaken everywhere in a given service area.

- 12.37. GPS had "Selective Availability" until 01/05/2000 ["references" 1.32]. *"GPS Selective Availability (SA) has not been used since its deactivation by the President on May 1, 2000. At that time, the United States Government stated that it has no intent to ever use SA again. There has been no change in this policy."* Selective Availability was an intentional degradation of public GPS signals implemented for national security reasons by the USA, having the effect of reducing precision of GPS of between 50m and 100m above any uncertainty already in the process. Selective Availability required specialist equipment to remove (e.g. military equipment was not affected as it could more accurately decode the signals). Any device without the decoding equipment, whether American, British etc. would be subject to SA. Applying an uncertainty of up to 100m on the location of a survey device, when using that device purely to assess the expected maximum range of a cell measured in many kilometres (or even tens of kilometres) would not in my view present any material issue to the reliability of the surveys conducted. INQ042494
- 12.38. The survey route was defined by PSNI. I do not have access to the resultant report and do not know what route was specified or why it was selected. I assume it was vehicle-based, and therefore based on roads. The approach was reviewed by Praesidium (INQ028453) which notes that calibrated equipment was used and the results were "as expected". I have no reason to question these findings, but the survey data is not included in the submitted material that I have considered; I would not expect it to have been included, as such data usually consists of large files of technically complex data that requires interpretation to be of use.
- 12.39. Data Handling. Survey equipment used today can generate large amounts of data with locations, dates and times of each measurement. It is common to deploy many pieces of survey equipment simultaneously, generating even more, examination-specific, data. This data can be retained in a database so that it can be used in other enquiries. Doing so enables more informed opinion to be made:
- 12.39.1. A more informed view as to where else the cell serves can be more easily made (i.e. it may be possible to illustrate the entire area over which the cell has ever been selected).
- 12.39.2. Cell service areas may change over time as sites are decommissioned or introduced, and there may have been a change between the time of the call and the survey. Overlaying "historical" data (potentially generated before the calls) with the "targeted" surveys

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(usually generated after the calls) may enable an assessment of possible network changes, or whether additional cells may also have served at a given location at a previous time.

There is no indication in the material considered that data such as this was available in 1998.

- 12.40. The overall conclusions after consideration of the survey data are low precision and expressed in terms of expected maximum range of a given cell. In my view the approach taken within INQ013302 and 013303 is appropriate for the capabilities of the method used and the type of conclusions given. In particular the reports make clear that i) cells serve areas and these areas are not known for sure and ii) some cells are bigger (and therefore findings less precise) than others.
- 12.41. I have not found any indication that historical survey data was available at or prior to the bombing. In the statement of Scott Southall of Vodafone, INQ013302 section 10, the Omagh Bombing was the only request of which he was aware and was therefore novel, at least to his knowledge. He travelled from England to perform the surveys which also implies that surveys were not routinely conducted by Vodafone in Northern Ireland even for non-Law Enforcement purposes.

Technical Opinion

A primary starting point in assessing whether a cell may (or may not) serve an area including a location is to consider:

- 12.42. The mast location of the cell site (available to the analysis). Available in the data.
- 12.43. The azimuth of the cell used; I have only found one reference in all of the data I have reviewed, and that was an estimation (apparently from a coverage prediction plot). Azimuth information does not appear to have been available for either the Omagh Bombing investigation and the R v Steele approximately two years earlier.
- 12.44. The height of the mast (currently included in some formats of Call Data, estimated from Google Streetview or by visiting the mast). Height data was provided for some cells, (but not all, of the cell details provided in INQ034428-34433 and was apparently used as part of the assessment, as outlined above. Streetview was not available in 1998, so if height data was not provided by the network, physically visiting the cell site may have been necessary to estimate it.
- 12.45. The geography of the terrain (hills), currently easily assessed from a desktop analysis using tools such as MemoryMap. The prediction tool would have used terrain, and consideration of geography is overtly discussed in the material I have considered, in particular surrounding the Omagh and Pigeon Hill cell sites.

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- 12.46. Environment; expected obstructions such as buildings ("clutter"). This is currently qualitatively judged on whether the location of interest is in the centre of a city, suburban, rural etc. and was known to those conducting the analysis. The prediction tool may also have used clutter in generating its estimates. Current methods include use of terrain to inform opinion (either as path profiles or viewshed analyses, functions of mapping tools). Radio signals do not pass through physical barriers (e.g. hills) well and in my opinion terrain blocking (e.g. a ridge higher than the cell site antenna) is a reliable method of assessing a maximum possible range for a given cell at ground level. The cell may not serve all the way to the ridge, but it is unlikely to serve on the other side of it at ground level (i.e. this does not exclude service on more distant hills or tower blocks that enable line of sight to the cell site). Such method was used within the original analysis. In INQ013303, the Vodafone engineer Scott Southall states that "The survey results show that in particular to the Omagh Cell Site on the Technical College...the coverage footprint is very limited due to two major factors. The topography of the land in and around Omagh is the major source of attenuation of the Omagh Cell Site radiated transmitted signal and the location of the Omagh Cell Site is at one of the lowest locations of the town". Furthermore, efforts were made to provide an indication of the precision of the findings by used of coverage prediction plots, such as those presented in INQ034428, INQ034429, INQ034430 & INQ034431, which would take terrain profiling into account.
- 12.47. The presence or absence of other cells in the area. More cell sites means more cells, and more cells means that service areas tend to be smaller as a phone hands over between cells sooner when it moves. I discuss cell service areas in greater detail below in section 12.41.
- 12.48. Survey Data. Survey data was used in the Omagh Investigation (INQ013302) and were conducted by the Network Operator. It was believed to be the first time surveys had been requested by any Law Enforcement Agency in the UK by those performing them. There don't appear to have been any surveys undertaken by the Prosecution for R v Steele, but such methods were available within the network for planning purposes and had been used by the Defence in the for R v Steele at least by the time of a report from November 1997. The methods used were a single SIM-based device and were used, in conjunction with coverage prediction plots, to estimate the maximum range of cells of interest.
- 12.49. Prediction plots were also used as part of the analysis for the Omagh investigation to provide indications of the service areas. Network operators use computer planning tools in order to predict the signal strengths from a given cell or, in combination, as "best server plots" (BSPs) showing the area over which a given cell is likely to be, on average, received at a higher signal strength than others. The results are a plot. The computer system used to do this takes into

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account the ground height, the radio propagation characteristics, the transmitter power, the antenna specifications, topography, building clutter and other cell sites in order to carry out the prediction and can also be refined using network measurements. Anecdotally (my source being my colleague Dr Brodie who was involved in the development of network planning strategies in a variety of roles from 1989 until he became a forensic scientist in 2007), the resolution of such prediction plots was typically in 50 metre squares, but may have been lower precision in the 1990s, potentially 200m squares in rural areas due to the resolution of the terrain data available.

12.49.1. When I was first conducting cell site analysis, I compared Best Server Prediction plots from a number of networks against their measured service areas i.e. I conducted large-scale surveys to measure the full extent where the cell of interest was selected as serving and compared it with the prediction. As a result of such testing, in my view this method is useful in network planning but as a forensic tool can mislead. The BSPs were always underestimates of the "true" measured service areas. This was not surprising to me or the team. A BSP will only give one cell in a given area as "most likely" but it is now an established expectation that many cells on a given technology and band provide service at the same point surveyed. As an example, six serving cells were detected in the research presented in "references" 1.9, but a prediction plot would only list one as a "Best Server" at that location. This implies that for five of the six cells detected the location at which the surveys were conducted wouldn't have been included in the predicted service area. These limitations were understood and discussed in the *R v Steele* ruling discussed in section 7.12.4.i) of this report, namely that prediction plots can help estimate service areas but they do not (and cannot) take into account all the other many variables to which the radio signals are subject. Prediction plots do not form part of current processes and I have not seen them in casework for decades (only once that I can recall in fact, and that was for a legacy case from 2003 that came to trial in 2019). In my opinion BSPs are not reliable enough indicators of service to be of practical use in current analyses, and the survey methods we have developed are a far better method.

12.49.2. Within the Omagh investigation, however, in my opinion is that the use of coverage prediction plots was appropriate for a number of reasons:

- i) Azimuth data was not available to the experts conducting the analysis. The coverage plots take into account the azimuth along with other information such as the mast height and surrounding terrain.
- ii) The conclusions drawn from the prediction tool were focussed on providing context on the general precision of findings rather than assessing whether the data might be expected if the phone was at a specific location. The findings were attempts to

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estimate the precision of findings and concerned general expectations of the service areas of a few specific cells.

- iii) Coverage prediction plots were used (estimating signal strengths) rather than BSPs (estimating the "strongest" cell which in my view could more easily mislead).
- iv) They were used in conjunction with survey data to provide a broad indication of their reliability.

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Forensic Inference

An overall conclusion of whether the data as a whole might be expected given the positions taken by Prosecution and/ or Defence, and the limitations to the conclusions drawn.

- 12.50. There is now an established Inference Model for safer approaches to opinion evidence, the Case Assessment and Interpretation (CAI) Model ["references 1.23, 1.24, 1.25 & 1.26] which is used in the Forensic Science Regulator's statutory Code as well as being endorsed by the Royal Statistical Society (RSS), Association of Forensic Science Providers (12.4P), the European Network of Forensic Sciences (ENFSI) and the Chartered Society of Forensic Sciences (CSFS). Guidance on the application of the model is also produced by some of the organisations listed above ["references" 1.19, 1.20, 1.21]. Inference Models were not available in 1998 and thus the reporting is of individual technical findings concerning the service areas of specific cells with (in my view commendable) discussion of the possible precision of findings when they were used. The conclusions I have read would be termed as "source" level and "investigative" rather than "evaluative" as might be expected given the CAI model . This means that rather than assess whether the data as a whole might be expected given the positions taken by both Prosecution and Defence (an "evaluative" assessment at "activity" level), the service area of each cell has been estimated ("source" level) so that hypotheses on areas in which the phone was can be speculated ("investigative"). In my view, given the low-precision findings this is lower risk than it otherwise might be if it were presented in current casework, where often the precision of findings is not presented. In any event the currently recommended interpretation model was not implemented in 1998 and I do not criticise the practitioners for forming opinions without having used it. Given the low level of call data to be considered I also view it as having minimal impact for this case.

Cell Service Areas

- 12.51. The networks themselves were in a period of rapid change in 1997 and 1998. There were fewer users, less capacity and a lower density of cell sites than now. This would affect general expectations of cell service areas, which in my opinion would be on average larger in 1998 than they are now (i.e. less discriminating). On page 4 of INQ000741, there is reference to an expansion of the UK Vodafone GSM network by 1,030 base stations, from 2,770 (3,800 total) between 1997 and 1998. For context, from other casework I have conducted I am aware that in 2020 there Vodafone operated well in excess of 30,000 cell sites. Within INQ027533, Simon Collins (Orange head of Central Operations in 1996) states that (at least on the Orange network) for mobile phones to use a given cell up to 7km from the mast, with cell sites spaced up to 14km

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to achieve this (page 2). Cell site density was far lower at the time of the Omagh bombing than now, I would therefore expect cell sizes to have been larger and resultant precision of findings lower. The average cell density is thirty times greater now than in 1997. This, together with routine retention of sector information, means that I would expect current service areas to be far smaller on average. Even in rural areas it is unusual to find cells providing service much further than 10km from the mast, and in urban areas the main body of service is usually less than 3km. Within the Omagh bombing analysis, "Pigeon Top" was estimated to potentially provide service all the way to the 35km maximum. In my career, I have only seen a few cells of this size.

- 12.52. A number of cells were assessed by practitioners as part of the investigation, and were believed to have extremely large service areas [INQ028453] compared to those I routinely observe. For example, cells based at "Pigeon Top" and "Cranlome Hill" were believed to serve out to the full extent (i.e. 35km); I have personally only ever encountered such large service areas in wild areas like Dartmoor. "Cavanacark" was believed to serve some locations out to 25km. Even the smallest cell discussed (based at Omagh Technical College) was believed to serve some locations 5-7km from the mast and this was based in a major town. These are, by current expectations, far larger service areas and therefore less discriminating when assessing the area in which a phone may have been.. Current expectations - in my view applicable from my first cases over 20 years ago- are for cell service areas to be of the order of
- Dense/Urban area - currently typically up to approximately 1km. Reasonable may have been much larger in 1998 (difficult to estimate, but not relevant to the Omagh investigation).
 - Suburban area - currently typically less than 3km, apparently 5km-7km in 1998 from the material reviewed.
 - Rural area - currently sometimes more than 10km, apparently up to 35km in 1998 from the material reviewed.
- 12.53. The expansion of the Vodafone network in the UK between 1997 and 1998 also indicates a rapidly and profoundly changing network meaning that expectations of the service area of a specific cell may change over short periods of time as new cells were introduced.
- 12.54. I had anticipated requesting a contemporaneous copy of "Sitefinder" from Ofcom for the purpose of comparing cell site density in 1998 with that within my direct experience. Unfortunately, and as discussed in 7.13, "Sitefinder" was not developed until 2000, and the Radiocommunications Agency that predated it did not routinely collect information on cell site locations (INQ011781, section 4.5). That said, INQ034432 provides the locations of all cell sites within 20km of the A5 between Omagh and Aughnacloy which provides an indication of cell site density specifically in this area.

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- 12.55. In my view, the assessments of cell service areas presented in the reports I have reviewed seem reasonable given the low precision of the estimates given and the lower cell density of 1998. I also believe that the low precision of findings also protects a little from the potential of network changes meaningfully affecting the reliability of the findings.

Reliability

The reliability of the conclusions drawn from the data considered is primarily dependent on the validity of the methods used, their completeness, the competence of those undertaking the examination and quality review.

Validation

- 12.56. Validation involves demonstrating that a method used for any form of analysis is fit for the specific purpose intended, i.e. the results can be relied on. For example, when I started work in this field in 2003 there was widespread use of a survey method where data was gathered by a static device close to a location of interest ("spot samples"). Survey results from the method were equated with the behaviour of the phone generating the call data considered and conclusions drawn accordingly. Prior to use in casework, the Forensic Science Service required that all methods were validated. When tested during validation exercises, this method was found to have very high false negative rates i.e. legitimately serving cells were routinely not detected serving using this method, with failure rates of well over 50% ("references" 1.9). This could result in conclusions that might mislead ("references" 1.11). Given that the method was in widespread use, in my opinion this demonstrates that there was not a culture of validation of methods for forensic use in the industry in 2003. I have assessed the reports in relation to the Omagh investigation with this as a potential concern. Within the analyses that I have reviewed there was independent review of the methods used and conclusions drawn (INQ028453) and in my view the conclusions are not of sufficient precision to make issues detected in later validations to make them unreliable. For example, 61451 "Pigeon Top" is listed as likely providing service out to the full 35km GSM limit (INQ028453, p12 paragraph 4.7), and even the more discriminating "Omagh" cell is discussed in terms of a precision of "5-7km", with terrain cited as the reason for the (comparative) higher precision. I have not tested these assessments, but in my view it is clear to me that they followed a sound process and so I have no obvious reason to doubt the opinions given.

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Completeness.

12.57. In my view the apparent lack of access to azimuth information is an impediment to more precise expectations. For example, the "Pigeon Top" cell discussed above is known to be sectorised. While it is reasonable that sector 1 may serve 35km from the mast, it is not likely that it served to 35km in all directions from it. That is to say, the main body of service would be expected to fan out from the mast location predominantly in the general direction of the azimuth of the antenna, and to be far less prominent behind the antenna. In short, the expected service area would be a sector of the circle rather than the whole circle itself (and even within this sector, would be unlikely to serve at all locations up to the full 35km). When multiple cells are used by a given phone close in time it may be possible to more precisely define the area in which the phone may have been. I have used this method to great effect in personal casework, but do not believe it was reasonable to do so within the Omagh Investigation. Within the data considered, there were no calls close enough in time to reliably do this, the absence of azimuth information would likely to make this approach ineffective, and the cell sizes were very large to begin with. For example, it is possible that a sector from the "Pigeon Top" cell may (with its expected range of 35km) have completely overlaid all of the sectors based at the "Omagh" cell site.

12.57.1. Cell Heights were available for some cells but not others. I assume these will have been from ground level. This is also useful in making estimations of cell service areas, in particular for assessing maximum likely extents of the main body of service.

12.57.2. End Cells. In current GSM data, I would expect to see the Cell ID used at the beginning and also the Cell ID used at the end for voice calls (for an example, please see slide 12 of MST/Cell_Site_Analysis_Explanation/241025). End cell information was not contained in [O16]1 (please see slide 10 of MST/Cell_Site_Analysis_Explanation/241025). I note that end cells are listed on page 16 of [INQ028453] from sources presumably other than [O16]1.

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Competency

12.58. In my view, there is no obvious reason to doubt the technical competence of those who undertook the analysis. The technical explanations of the operation of the network and limitations of the traces considered are clear, appropriate and comprehensive. The experts conducting the work, while operating outside a formal forensic environment (and thus with a few caveats concerning validation, lack of inference models, use of language such as "consistent" or directly addressing propositions rather than whether the data might be expected given them), appear to have been acting with skill, knowledge and integrity.

Review

12.59. The original analysis was independently reviewed by Praesidium Services. The data was re-analysed by independent experts in 2008 and again in 2015. By this date cell site analysis a mainstream analysis and were applied to the Omagh Bombing as part of Breslin. The data has been analysed and re-analysed.

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Overall Conclusions - Reliability of Cell Site Analysis used in the analysis

12.60. Taken as a whole and through the lens of core current statutory requirements defined in section 5.5, my view of the reliability of the analyses I have reviewed are as follows:

12.60.1. Balance. There are no propositions defined as is required in a current analysis. This is unsurprising as the CAI inference model from which this current requirement stems had yet to be implemented anywhere in the world at the time of the bombing, even within the Home Office Forensic Science Service where it was being developed. In the context of Cell Site Analysis this means that, contemporaneously and for evidential use, we should be assessing whether the data as a whole is expected given the positions taken by Prosecution and Defence, rather than using the data to predict where the phone is. The cell site analysis for the Omagh bombing comprised of a series of estimates of areas within which a given phone was believed to be operating, with an emphasis on the uncertainty of those estimations. There is no stated position for the defence concerning the phones to test that I have found. In my view the low precision of findings (large estimates for service areas and low number of call events available for consideration), emphasis on uncertainties and the manner in which they were expressed mitigates for the lack of stated propositions.

12.60.2. Logic. I have not found any examples of failures of logic (i.e. Transposed Conditionals or "the Prosecutors Fallacy") in any of the material I have considered. For example, the analyses do not claim that a phone was in Omagh because a given cell was believed to serve there (which would be a transposed conditional), but that the Omagh was in the service of that cell, along with a wider area (which is not a transposed conditional). The manner in which the technical opinion is expressed is sound and logical.

12.60.3. Transparency. In my view the clarity concerning the methods used, the uncertainties within those methods and the call data considered (e.g. uncertainty in cell size estimations and the discussions concerning transcription of the call data in **016**/1) is exceptional. Overt opinion is provided where opinion is required for the findings to be of use and that opinion is based on declared, detailed and in my view appropriate knowledge.

12.60.4. Robustness.

i) Competence. A current requirement would be to demonstrate competence prior to conducting casework. I do not know what, if any, competency assessments had taken place for the practitioners doing the work. In my view, from the review:

- Skills. These are self-evident by the ability to conduct and present the analysis.
- Knowledge. There is demonstrable deep subject matter knowledge of radio telecommunications, network information like toll tickets and radio propagation.

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- Understanding. Technical understanding is evident in the discussions surrounding the uncertainties within their analyses. Forensic Understanding is discussed above under "Balance" and "logic".
- ii) Validity of methods. I have no information to suggest that the methods used were validated. That said:
- CDR normalisation. My own analysis agrees with that presented in the evidence considered. "Other party" data was correctly identified and removed.
 - Mapping. My own analysis agrees with that presented in evidence.
 - The use of terrain data to inform estimates is in my view a sound approach especially when combined with other information (e.g. survey data and coverage prediction plots).
 - Surveys. A single device was used. As outlined in section 12.34, a single device is prone to "false negatives" (underestimates of the true service area) but I would expect this effect to be far less pronounced in the less developed networks of 1998. The survey data was used to test estimates from predictions which included terrain profiling, in my view largely mitigating for this issue.
 - Spot samples, in my opinion a deeply flawed method, were widely used when I started work in this field a few years later, but were not used in the analyses reviewed.
- iii) Quality Assurance. I do not know what checking process, if any, was applied prior to issue of the material I have reviewed, but the analyses were subject to extensive and detailed defence review and I have reviewed the detail of some aspects. It has not been possible to test all aspects (e.g. I cannot perform a survey that would be relevant to the state of the network in 1998), but agree in those aspects that I have personally reviewed.

12.60.5. In short, while the analysis is not presented in the form required for a current case, I find no indications that the findings and opinions given are unreliable. None of the technical issues identified during my career are evident in the material I have reviewed. In my view the estimates of service areas are based on sound principles and are of justifiably low precision (e.g. 35km for the "Pigeon Top" cells).

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12.61. To summarise, in my view at the time of the Omagh investigation in 1998:

- 12.61.1. Cell Site Analysis was available during investigations of a serious nature, and was conducted for the Omagh Bombing. *Cell Site Analysis appears to have been in widespread investigative use by 1998 but was not in common evidential use at that time; indeed evidential use was actively discouraged.*
- 12.61.2. Such analyses had been used since at least 1992, but were "sensitive" and could only be used at court with special permission. Usage at court at all was resisted. For example Orange in their policy statement of 1996 (INQ027532) did not want any data to ever be disclosed at all. I do not have policy statements from other network operators but there is no reason to believe this was different for other operators *and evidence from the ACPO Telecommunications Industry LEA Focus Group is clear that Cell Site Analysis would be provided "for intelligence purposes only, and should not be adduced as evidence to be disclosed to the defence".*
- 12.61.3. Modern smart phones usually generate far more call events for data connections than for voice calls and text messages. There were no smart phones in 1998, and no data connections in the toll tickets considered. Cell site analysis at the time of issue of this report usually has more data to consider. The density of cell sites in 1998 was far lower than is currently the case; cell service areas were therefore also routinely larger. Cell Site Analysis was far inherently less precise in 1998 than is currently the case as a result of these factors.
- 12.61.4. Surveys were possible, but there is nothing to suggest widespread use and in fact an indication that the Omagh investigative were early adopters (amongst the first for Prosecution purposes to my knowledge).
- 12.61.5. There is no reason to doubt that the interpretations and opinions given were informed by technical knowledge. Limitations were clearly stated and appropriate.
- 12.61.6. Cell Site Analysis was a work in progress in 1998. There is no indication in any of the material I have considered that methods used in the Omagh Bombing Investigation were anything other than developmental, and a number of times when they were described as first-time requests (data collection; page 20 of INQ013044, surveys; page 2 of INQ013302). In my view there are indications that competent individuals were applying potentially groundbreaking methods to casework and showing initiative to do so.
- 12.61.7. I have found no evidence that indicates the findings are unreliable.

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13. Identification of the user of Mobile Phones

Explain how the user of a mobile telephone might have been identified in 1997 and 1998, whether through a subscriber check, IMEI number identification, call pattern analysis, home cell site analysis or in any other way.

- 13.1. Subscriber check. The first and most obvious step in identifying the user of a given phone is to ask the network with whom the contract is held. The detail may not be accurate (i.e. the subscriber may misrepresent their identity). I understand that Pay As You Go was introduced by Vodafone in 1996, for which subscriber details are not required. I believe that this type of enquiry would have been possible in 1998. The IMSI, MSISDN or IMEI can be used to identify Call Data Records of a phone known to be of interest to an investigation.
- 13.2. Numbers in contact. The numbers with which a mobile phone is in contact are indicated in the Call Data. Subscriber checks can be made for both landlines and other mobile phones indicated in this data. Within those subscribers there are investigative opportunities including businesses who may have detail of the caller (e.g. taxi firms, doctors, anyone requiring an appointment etc.) as well as identification of family networks or known groups of associated individuals. I believe that this type of analysis would have been possible in 1998.
- 13.3. Commonly listed Cells. There is a general expectation that cells providing service over an area including the home or work address of the user (or their partner's or family addresses) would figure prominently in the Call Data Records for the phone in question.
- i) A summary of the most listed cells and/ or cell sites can be compiled. More detailed analysis can take place, including estimation of specific cell service areas. If commonly listed cells do not overlap, according to the time of use, this may enable identification of areas in which the user lives and works. This type of analysis would have been possible in 1998, although the precision is likely to have been much lower due to larger cell sizes and less developed techniques to actively assess service areas.
 - ii) It is accepted for current analyses that many cells are likely to serve at a given location. The areas of overlapping cell service areas can enable more precise estimation of the "home" and "work" areas. When I started reporting in this area approximately 20 years ago, there was an established and widely held misconception that only a single cell would normally provide service at a given location prior to publication of a paper in 2012 ["references" 1.9]. This misconception was not held by the expert producing INQ028453, p6 (a report by Praesidium Services) who explicitly states the expectation of many cells providing service at a given location in paragraph 2.15. INQ042494

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13.4. Once a suspected user is identified, the investigative theory can be tested by comparing the call data of the alleged phone to:

- i) Known locations of the suspect. These may be observations, CCTV, locations identified by financial data (e.g. hotel stays), known travel (e.g. train tickets, bus tickets, plane tickets including roaming international travel).
- ii) Known locations of the suspect's vehicle. ANPR had been implemented in parts of the UK, being used to identify a stolen car in 1981. ANPR networks would not have been as established in 1998 as they are today but analysis of the data may still have been an option.
- iii) Accepted phone data, if one exists.
 - a. "Clean phone vs. Dirty phone" cell site comparison is a common assessment for me to undertake throughout my career.
 - b. Comparison of IMEI in case of SIM swapping. IMEI is discussed below.
- iv) Known life pattern (e.g. work shift patterns, hospital appointments etc.).

There is no reason to believe that this type of analysis would not have been possible in 1998, but would have been less efficient, precise and reliable than using current methods.

13.5. IMEI. IMEI stands for International Mobile Equipment Identity. It is a 14-digit electronic serial number and is embedded in the hardware of the mobile phone handset, potentially with additional digits (either as a checksum or indicating software version).

- i) The IMEI is unique to each handset and is unrelated to the subscriber's identity as contained in the SIM card, which relates to the phone number. Each time a call is made the IMEI is checked on the Equipment Identity Register, which stores all valid IMEI numbers on that network. The IMEI is shown on call data records for certain networks against a phone registered on that network when making or receiving calls. IMEI numbers may not be recorded for diverted events (e.g. calls to voicemail).
- ii) The IMEI can be of use in an investigation in a number of ways. For example:
 - a. It can be used to detect if a given SIM card has been used in different handsets, which is potentially of use in attribution assessments ("SIM swapping").
 - b. The type and model of phone can be determined to understand its capabilities.
- iii) Currently, each time a call is made the IMEI is reported to the network and may be checked against the Equipment Identity Register. While usage of phones requires cross referencing of the IMEI for the phone in use with an Equipment Database -

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meaning that handsets reported stolen can be barred. With specialist equipment, IMEIs can be reprogrammed. As usage of mobile phones became widespread in the nineties, so did theft of them. IMEI reprogramming was made an offence under the Mobile Telephones (Re-programming) Act 2002.

- iv) Prior to 2002 (i.e. in the period considered for the Omagh Bombing) the format of the IMEI was different to that currently used ["references" 1.35, 1.36] but was still a unique number capable of identifying the make and model of device.
- v) IMEI information wasn't included in the Toll Ticket data that I have considered.

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14. Access to Text Messages and Voicemail.

14.1. *Explain whether the authorities in 1997 and 1998 had the ability to access text messages (and similar) and voicemails made and/or received by mobile telephones, and whether that was dependent on having access to the handset itself.*

14.2. **Access to Text messages. I understand that:**

14.2.1. Text messages are handled by the networks' short message service. In 1998, this would be the GSM system; TACS is not capable of supporting text messages. Messages generated and sent by a user are delivered to and stored by the network, placed in a queue, and then delivered to the recipient, usually within a few seconds. The process of delivery can occur even if the recipient mobile is engaged in a voice call. If the receiving mobile is off, or out of coverage, then the message cannot be sent and will be stored for a pre-determined time before another attempt is made to deliver the message. After an extended period, usually a day or two, if the message still cannot be sent, it will be deleted from the queue and not sent. Once a message has been delivered, a receipt is sent back to the network so that the message can be deleted from the queue, this also enables any further stored messages waiting to be sent. Text messages that are not delivered will not show as incoming text messages in call data records. The network will not attempt to send a text message to a mobile that has been switched off, but will commence sending any stored messages once it is switched back on. If a mobile is unable to acknowledge receipt of a text due to being in an area of poor coverage, then the same message may be sent repeatedly, although this will not show as an incoming text message received. Data recorded relating to text messages varies significantly between networks, some may not record the Cell ID associated with the text, while others show all details including the delivery receipt acknowledgement. Within INQ000433, there is an example of a received text message (call 17), but that record does not list a Cell ID.

14.2.2. In 1998, text messages (Short Message Service, SMS) were less prevalent than they are now. Initially text messages could only be sent to subscribers on the same network; this restriction was lifted in 1999. In 1995 customers sent on average only 0.4 messages per calendar month, rising to 35 per month by the end of 2000 ["references" 1.37, 1.38]. INQ042491

14.2.3. TACS was a voice only system (i.e. there were no text messages, which were first introduced using GSM).

14.2.4. On GSM, text messages are held on a "store and forward" platform and can be accessed remotely with appropriate legal authority (e.g. IPA). I have no reason to believe that this was not also possible in 1998, although the legal process would have been different (I assume DPA). Text messages stored on mobile phones can be recovered via direct

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examination of the SIM card and handset. I was involved with this type of examination in the early 2000s.

14.3. **Access to voicemails. I understand that:**

14.3.1. Voicemails on GSM are held on a platform and can be accessed remotely by the user. With appropriate legal authority my understanding is that access to voicemails is possible under IPA (formerly RIPA). Remote access is currently possible, and I believe that this was the case from the beginning of the service, although the legal process would have been different.

14.3.2. TACS was an analogue system. I do not have knowledge of the technical details of this system. I understand that it did have a voicemail platform, and that users were notified of messages via a pager system, but I have not found a reference for this.

Signature

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END OF REPORT