Scientific Working Group on Digital Evidence

Core Competencies for Historical Cell Site Analysis

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1. Purpose

The purpose of this document is to define the core competencies required for practitioners conducting historical cell site analysis and mapping. It establishes the knowledge, experience, and training necessary to obtain, process, interpret, verify, document, and present cell site location information (CSLI) derived from cellular service provider records in a manner that is scientifically sound, legally defensible, and ethically responsible.

2. Scope

This document defines the core competencies for historical cell site analysis using records maintained by cellular service providers. It focuses exclusively on cell site data and does not constitute a complete training manual, replace agency procedures, or address mobile device forensics.

These competencies may be applied in support of, but are not limited to:

- Criminal investigations
- Civil litigation
- Intelligence analysis
- National security investigations
- Missing persons investigations
- Public safety operations
- Internal investigations
- Expert witness testimony

Refer to *SWGDE 17-F-001-5.0 Best Practices for Historical Cell Site Analysis and Related Best Practices* for detailed technical guidance. These competencies are written to the evidentiary standard, reflecting the rigor required when findings may be presented as evidence rather than used solely to guide an investigation.

3. Limitations

This document addresses the competencies expected of practitioners who conduct historical cell site analysis. It does not describe how to perform the analysis; the technical methodology is addressed in *SWGDE 17-F-001-5.0 Recommendations for Historical Cell Site Analysis*.

This document does not address the analysis of data recovered from a mobile device, which is addressed in *SWGDE 18-F-003-2.0 Best Practices for Mobile Device Evidence Collection & Preservation Handling and Acquisition* and *SWGDE 20-F-005-2.0 Best Practices for Mobile Device Forensic Analysis*. It does not address real-time location techniques, including pen register, trap and trace, or device pings, except to the extent a practitioner must recognize such records when they appear in provider productions. It does not constitute a training manual, a training curriculum, or a substitute for the policies of the practitioner's organization.

Because cellular technology and provider record formats change continuously, the specific record types, data elements, and network technologies described in this document are current as of the date of publication.

No studies evaluating the performance of practitioners assessed against the competencies described in this document have been completed as of the date of publication.

4. General Considerations

CSLI analysis shall be conducted only by qualified practitioners with documented training and experience. All work must comply with applicable laws, agency policies, and ethical standards. Practitioners who recognize that a matter falls outside their area of expertise are encouraged to collaborate with more experienced colleagues. Technology and carrier data formats evolve; ongoing education and training is required. When commercial software is used for mapping CSLI, verification of results through manual mapping or independent tools is recommended. Documentation must be sufficient for independent review, admissibility, and related legal challenges.

5. Core Competency Areas for Historical Cell Site Analysis

5.1 Training

The specific duties of some practitioners do not include authoring search warrants or subpoenas; however, all practitioners shall have knowledge of the following:

- The legal mechanisms by which CSLI is obtained, including preservation requests, subpoenas, search warrants, court orders, emergency disclosures, and consent-based production.
- Business-record admissibility requirements, including carrier affidavits, cell site lists, carrier-specific reference sheets, and record legends necessary to authenticate and interpret provider data.
- Evidence handling in accordance with organization policies, applicable laws and *SWGDE 17-F-001-5.0 Best Practices for Historical Cell Site Analysis*.
- Applicable privacy statutes and ethical obligations, including the duty to accurately represent the precision and limitations of location inferences.
- The obligation to disclose limitations, assumptions, and uncertainties in all reports and testimony.

5.2 Legal Considerations and Ethical Standards

The specific duties of some practitioners do not include authoring search warrants or subpoenas; however, all practitioners shall have knowledge of the following:

- The legal mechanisms by which CSLI is obtained, including preservation requests, subpoenas, search warrants, court orders, emergency disclosures, and consent-based production.
- Business-record admissibility requirements, including carrier affidavits, cell site lists, carrier-specific reference sheets, and record legends necessary to authenticate and interpret provider data.
- Evidence handling in accordance with organization policies, applicable laws and *SWGDE 17-F-001-5.0 Best Practices for Historical Cell Site Analysis*.
- Applicable privacy statutes and ethical obligations, including the duty to accurately represent the precision and limitations of location inferences.
- The obligation to disclose limitations, assumptions, and uncertainties in all reports and testimony.

5.3 Foundational Skills

Practitioners' foundational skills shall include:

- Knowledge of cellular network architecture and standards, including GSM, 4G LTE, and 5G NR, as well as distinctions between facilities-based carrier infrastructure and MVNO operations.
- Core technical terminology, including cell site, sector, azimuth, horizontal beamwidth, timing advance (TA), call detail record (CDR) formats, and data available through similar carrier systems.
- The data elements contained in carrier records, including date and time fields, serving cell and sector identifiers, and time zone reporting conventions.
- The structure and use of cell site lists and carrier guides, and the application of automated mapping tools in conjunction with those records.
- Knowledge of radio frequency propagation principles, including how the following may impact coverage area or data interpretation: tower height, antenna configuration, terrain, attenuation, multipath propagation, and distributed antenna systems (DAS).

Practitioners shall have an understanding of their own limitations and knowledge gaps, which are addressed by obtaining direct training, education, and experience in historical CSLI analysis as opposed to training, education, and experience in other digital forensic or engineering disciplines.

5.4 Evidence Identification

Practitioners identifying evidence for cell site analysis shall be able to:

- Identify and request the full range of relevant carrier records, including subscriber information, CDRs, timing advance data, cell site lists, reference sheets, and proprietary location estimates.
- Understand the information necessary to support legal demands for carrier records, specifying time ranges, data types, and cell site information contemporaneous with the period under analysis.
- Identify applicable carrier retention periods and initiate timely preservation requests to prevent loss of potentially relevant data.
- Understand the different record formats provided by each carrier, the type of data included in each, and the appropriate interpretations of the records.

5.5 Processing Records

Practitioners processing data for investigations and legal proceedings shall be able to:

- Review carrier-produced records for specific data formats and coding conventions and apply appropriate time zones.
- Apply automated tools appropriately, with manual verification of tool output against source records.
- Prepare data for mapping and visual presentation while maintaining the integrity and traceability of original records.

5.6 Interpretation and Analysis

Practitioners interpreting and analyzing records related to cell site analysis shall be able to:

- Distinguish between omni-directional and sectorized cell site configurations and correctly interpret their analytical implications.
- Interpret azimuth and horizontal beamwidth to define the general area associated with a network interaction.
- Apply timing advance measurements to infer device-to-cell site distance, expressed as arcs within sectors, and articulate the assumptions and measurement uncertainty inherent in such estimates.
- Be able to explain how certain factors, including neighboring cell site configurations, and radio frequency propagation characteristics, affect network interaction patterns.
- Reconstruct relevant event timelines and assess movement patterns based on the totality of the records.
- Evaluate data quality, identify anomalies or inconsistencies in carrier records, and assess their potential impact on analytical conclusions.
- Identify contextual information such as relevant locations, timelines, and other sources of relevant digital evidence.

- Clearly and accurately characterize the limitations of any inferences drawn from CSLI.

5.7 Documentation

Practitioners documenting cell site analysis shall:

- Maintain contemporaneous case notes documenting methodology, tools used, data sources, assumptions, verification steps, and any deviations from standard practice.
- Be able to produce a report that includes references to all source data used, mapping exhibits, and explicit statements of limitations and uncertainties.
- Maintain a curriculum vitae reflecting relevant qualifications, and expert testimony.
- Archive all working files, source records, and analytical outputs in accordance with best practices and applicable agency or organizational policy.

5.8 Presentation and Testimony

Practitioners presenting and testifying to cell site analysis shall be able to:

- Prepare accurate and clearly labeled demonstrative exhibits such as maps, timelines, and sector diagrams, to assist a finder of fact in understanding the analysis.
- Explain technical concepts and methods clearly to a non-technical audience, including judges and juries.
- Articulate the analytical methodology, verification processes, and all limitations and uncertainties of cell site analysis in a manner consistent with the standards under the applicable admissibility framework (i.e. Daubert, Frye, or their corresponding state corollaries).
- Respond to cross-examination and admissibility challenges with accuracy, consistency, and transparency.
- Present findings and opinions impartially.

6. Court Precedent

Courts increasingly treat historical cell site analysis as a subject requiring expert, rather than lay, testimony. In *State v. Hannah* [1], the New Jersey Supreme Court unanimously held that, under N.J.R.E. 702, cell site location information "involves technical and specialized knowledge that must be presented to a jury by an expert witness," reasoning that "the technical and specialized knowledge required to interpret CSLI is beyond the ken of the average juror." The Court rejected the practice, permitted in some jurisdictions, of allowing a lay witness to simply plot cell site locations from provider records, concluding that a jury cannot meaningfully evaluate such evidence without an explanation of how cellular networks operate, the factors that affect which cell site a device connects to, and the limitations of the technology. Although *Hannah* is binding only in New Jersey, it reflects the evidentiary standard to which these competencies are written. Practitioners should expect that their training, experience, and methodology may be scrutinized

under the applicable expert-witness rule (e.g., Fed. R. Evid. 702 [2] or its state equivalent) and should be prepared to be qualified as an expert whenever CSLI findings are offered as evidence.

7. References

[1] State v. Hannah. A-44-24, Supreme Court of New Jersey, 16 Apr. 2026. *Official Website of the New Jersey Judiciary*, https://www.njcourts.gov/system/files/court-opinions/2026/a_44_24.pdf.

[2] Fed. R. Evid. 702. Testimony by Expert Witnesses. Amended 1 Dec. 2023. *United States Courts*, https://www.uscourts.gov/forms-rules/current-rules-practice-procedure/federal-rules-evidence

8. Additional Resources

- Scientific Working Group on Digital Evidence. *Best Practices for Historical Cell Site Analysis*. SWGDE 17-F-001-5.0. SWGDE, 2026, https://www.swgde.org/17-f-001-5-0/
- Scientific Working Group on Digital Evidence. *Best Practices for Mobile Device Evidence Collection & Preservation Handling and Acquisition*. SWGDE 18-F-003-2.0. SWGDE, 2025, https://www.swgde.org/documents/published-complete-listing/18-f-003-2/
- Scientific Working Group on Digital Evidence. *Best Practices for Mobile Device Forensic Analysis*. SWGDE 20-F-005-2.0. SWGDE, 2026, https://www.swgde.org/documents/current-documents/

9. History

Revision	Issue Date	History
1.0 DRAFT	5/13/2026	Initial draft created.
1.0 DRAFT	9/3/2026	Court precedent added. Reference added. SWGDE membership voted to approve as a Draft for Public Comment.
1.0 DRAFT	10/26/2026	Formatted for release as a Draft for Public Comment.