

Chapter 2

Geospatial Technologies in the Courtroom

George Roedl, Gregory A. Elmes, and Jamison Conley

Abstract The function of a court is to resolve disputes through a legal process. With few exceptions, the progression of a legal case will follow the strict guidelines of rules and codes developed from numerous court decisions to fairly and efficiently securing a just determination. All federal courts adhere to a flexible set of rules published in the Federal Rules of Evidence (FRE). The FRE provides rules and definitions governing general provisions, judicial notice, presumptions, relevance, privileges, witnesses, expert witnesses, hearsay, and authentication. However, there are as yet no special rules governing the use of geospatial technologies or spatial data. From a pragmatic legal perspective, spatial data differs immensely from the traditional form of evidence. However, the power of spatial information is extremely persuasive and compelling in litigation. While the acceptance of spatial data and methods has increased in litigation, there are also several issues that merit careful consideration when using spatial data. This chapter examines key rules and court decisions that impact the potential admissibility of spatial data and technologies in a modern courtroom.

Keywords Admissibility • Rules of evidence • Demonstrative evidence • Scientific evidence • Computer-generated evidence • Frye test • Daubert • Expert witness

2.1 Introduction

Crowsey (2002a) described spatial information as one of the most powerful comprehension and communication tools available to legal practitioners. The likelihood of a successful litigation is greatly enhanced through an effective means

G. Roedl (✉) • G.A. Elmes • J. Conley
Department of Geology and Geography, West Virginia University,
330 Brooks Hall, Morgantown, WV 26506, USA
e-mail: groedl@gmail.com; greg.elmes@mail.wvu.edu; jamison.conley@mail.wvu.edu

of communication and visualization that aids in a greater understanding of the truth (Crowsey 2002b; Cohen 2008). Spatial technologies, and the associated spatial information derived from spatial technologies, provide the tools and methods for persuasive communications by those who adopt them as well as harm those who are hesitant to adopt them (Crowsey 2002a; Gonzalez 2009). When effectively and properly used, spatial information is capable of providing a persuasive understanding of the facts of a case (Crowsey 2002a, b; Cohen 2008). Fiedler (2003) described humans as visual learners who prefer visual evidence, citing an 87 % retention rate of visual information as opposed to only a 10 % retention rate of oral information alone. Pratt (2001) acknowledged information retention rate statistics as the difference between winning and losing a case. On the other hand, however, effective visual information communication may be the admissibility of spatial tools and data in legal proceedings requires an understanding of proper procedures. Since judiciaries from one country to the next can vary, a discussion of procedural processes and the admission of spatial data in courts is necessarily restricted. Cho (2005) provides an introduction to spatial law, legal systems, and legal theories of various jurisdictions around the world, whereas this chapter addresses the legal system in the United States exclusively.

The function of a court is to resolve disputes through a legal process. Based on the English common law court model, the US court system uses an adversarial process in which facts are presented to a judge and jury in a persuasive manner intended to support an argument effectively or to refute an opponent's argument. The role of the court in an adversarial system is to act as an impartial referee for the parties presenting facts in a dispute to ensure due process is followed. There are two basic types of courts: criminal court¹ and civil court.² In a criminal court, the adversaries presenting facts are the prosecutor and the defender. The prosecutor provides compelling evidence to support accusations of illegal activities by the defender. If the prosecutor successfully presents a persuasive argument, the defender can be punished through fines or imprisonment. Therefore, criminal court cases require a prosecutor to provide proof beyond a reasonable doubt to help ensure an innocent defender is not punished. By contrast, a civil court resolves disputes between parties in which one party prevails by providing the most compelling argument which supports their position more favorably than the opponent's argument. The judge serves as the fact finder to first determine if a party was wronged and then either assesses damages or issues a judicial order to start or stop an action petitioned to the court (Cohen 2008). For example, in a car accident between two citizens, the judge would listen to arguments on each side to first determine who was at fault and then make a decision as to what the remedy should be (e.g., repair costs).

Both criminal and civil courts can hold two types of trials. The first type of trial is a trial by jury. In a trial by jury, ordinary citizens are called upon to become fact finders. For criminal cases, a trial by jury is standard with few exceptions. Because

¹ See also <http://www.uscourts.gov/uscourts/rules/criminal-procedure.pdf>

² See also <http://www.uscourts.gov/uscourts/rules/civil-procedure.pdf>

selecting jurors is a lengthy process and not all trials (e.g., probate) necessitate a jury, bench trials are an alternative. In a bench trial, a judge serves as the finder of facts and administrator of justice. Every US state has a court system making criminal and civil trials available. In addition to state courts, there are federal district courts which preside over trials of specific matters. District courts preside over cases involving constitutional law, treaties, maritime law, interstate law and cases, and cases in which the US government is either the plaintiff or defendant. There are currently 89 districts and 94 district courts in the United States. There are also an additional 13 (11 district, 1 D.C., and 1 federal) judicial courts (also called circuit courts or courts of appeals) which preside over district court cases that have been appealed when issues regarding errors in the law are suspected (e.g., misinterpretation of a constitutional amendment or overstepping/lack of jurisdictional authority).³ A US court of appeals typically serves as the final arbitrator for most federal cases and often sets legal precedent through its decisions (Hemmens et al. 2007). Unlike state and federal courts, an appeals court does not hold trials. Decisions are determined entirely through records presented at the lower court, although attorneys may be permitted to provide a brief oral argument. After an appeals court reaches a decision, either party may apply to the US Supreme Court to review the decision. Although a lengthy discussion of the judicial hierarchy may seem extraneous in a work on forensic GIS, it is important to establish the implications of decisions. It should now be clear that district courts only hear certain types of cases, while an appeals court is a much more powerful entity that sets legal precedent and policy after reviewing select cases, typically dealing with constitutional liberties.

2.2 Admissibility of Evidence

With few exceptions, the progression of a legal case will follow the strict guidelines of rules and codes developed from numerous court decisions (Cohen 2008). All federal courts adhere to the rules for admissibility adopted by the US Supreme Court and published in the Federal Rules of Evidence (FRE).⁴ FRE Rule 1101 specifies which courts, judges, cases, and proceedings are required to adhere to the FRE, as well as the only three exceptions (a preliminary question of fact governing admissibility, grand-jury proceedings, and miscellaneous proceedings such as issuing an arrest warrant). The purpose of the FRE, as stated in Rule 102, is to “administer every proceeding fairly, eliminate unjustifiable expense and delay, and promote the development of evidence law, to the end of ascertaining the truth and securing a just determination.” State court systems adhere to similar sets of published rules (e.g., Rules of Civil Procedures) based on the FRE (Onsrud 1992). The current edition of FRE contains 68 rules.

³ See also <http://www.uscourts.gov/uscourts/rules/appellate-procedure.pdf>

⁴ Federal Rules of Evidence. Amended 01 December 2012. Available at <http://www.uscourts.gov/uscourts/rules/rules-evidence.pdf>. Accessed 20 September 2013.

In theory, evidence which is relevant and not excluded by any of the FRE is admissible (Levi et al. 2013). Evidence may be admissible as either scientific evidence or demonstrative evidence. Scientific evidence is substantive evidence having probative value in and of itself, while demonstrative evidence is meant to clarify or illustrate testimony and has no probative value (Dischinger and Wallace 2005; Pratt 2001). Presented to prove or disprove a matter at issue in court, scientific (substantive) evidence comes in the form of testimonial evidence (e.g., oral testimony), documentary evidence (e.g., written testimony), or real evidence (e.g., a physical object) (Pratt 2001). Demonstrative evidence comes in the form of illustrative evidence (e.g., photographs) and actual evidence (e.g., confiscated items). Since scientific evidence has independent probative value, it becomes part of the formal record which may be examined by a deliberating jury. The jury is then able to review the facts revealed through the scientific evidence to aid in determination of guilt or innocence and liability (Bird 2001). In contrast, demonstrative evidence is rarely available during deliberations since it has no probative value.

Both scientific evidence and demonstrative evidence must be deemed relevant, authentic, and accurate and reliable (commonly referred to as foundation) in order to be admissible (Markowitz 2002; Dischinger and Wallace 2005). Depending upon the manner in which they are used, geospatial technologies can provide scientific evidence, demonstrative evidence, or both. When spatial data is merely used to illustrate and clarify testimony, it is admissible as demonstrative evidence (i.e., illustrative evidence). However, when used to prove the existence of a fact (e.g., a GPS tracking log) or as the basis of an expert opinion or conclusion, spatial data becomes scientific (Pratt 2001). Admitting spatial data as scientific evidence in a trial is more difficult than admission as demonstrative evidence and is largely dependent on having an expert witness testify about the facts (e.g., authenticity and accuracy) of the data (Dischinger and Wallace 2005). However, spatial data gathered from geospatial technologies may be granted greater admissible probative value when there is minimal human interaction with the data, such as raw satellite images (Krouse et al. 2000).

Spatial data generated from geospatial technologies, such as GIS, GPS, and remotely sensed data, are considered computer-generated data as well as digital data since computer technology is used to create the data which is stored digitally. Pratt (2001) referred to CGE as an abbreviation applicable to computer-generated evidence (also referred to as computer-generated exhibits), a broad term encompassing any use of computers in producing evidence for litigation. The Committee on Identifying the Needs of the Forensic Sciences Community (2009) referred to digital data as the digital evidence (e.g., photographs, call logs, and location records of a device) that could be gathered, processed, or interpreted from digital devices, such as desktop and laptop computers, cell phones, digital cameras, GPS devices, portable media players (e.g., iPods), etc.

Although Chap. 1 characterized spatial data as digital data, it is worthwhile to make a distinction between spatial data and the computer-generated end product derived from spatial data (generated by geospatial technologies) that may ultimately be admitted into court. For example, digital maps would be considered digital data representations of reality, whereas animated maps may be considered computer-generated data. Additional examples could include models which combine spatial

data with mathematical formulas and 3-dimensional visualizations or virtual reality. The implications of this distinction may have a direct bearing on ease of admissibility under the FRE. Consider a simple digital photograph displaying erosion caused by a stream. The photograph represents the stream as it appeared when the image was taken for the given spatial location. Next consider a model which combines several spatial data sources (e.g., elevation, soil classifications, slope, average rainfall, land cover) with a mathematical model to predict the erosion of a stream. The accuracy of the source data and any transformations of the data; the choice; the quality and reliability of the mathematical model, e.g., the Water Erosion Prediction Project Model or the Universal Soil Loss Equation (Flanagan et al. 2001); the uncertainty of parameters input into the model; the error associated with the procedure; and the qualifications and experience of the modeler can drastically reduce the chances of the model being admitted into court as an accurate representation of erosion, since any of the pathways leading to speculative results could be challenged. Since the digital photograph experiences less human intervention, courts are more inclined to consider admitting it into evidence (Crowsey 2002a).

Before geospatial technologies can be used in court, they must first be allowed to be admitted into court as evidence. Although all rules are applicable to legal proceedings (Rule 1101 provides for applicability and exceptions), Spencer (2006) identified eight specific rules potentially applying to the question of admissibility of data derived from geospatial technologies. However, an additional four rules may also be applicable. The 12 rules are 401, 402, 403, 611, 702, 703, 801, 802, 803, 804, 901, and 1006.

2.2.1 Rules 401, 402, and 403

FRE Rule 401 is the test for relevance of evidence in court. Prior to the current version of the FRE, Rule 401 simply stated the definition of “relevant evidence” as “evidence having any tendency to make the existence of any fact that is of consequence to the determination of the action more probable or less probable than it would be without the evidence.” The new Rule 401 has been amended to include two conditions: (1) “it has any tendency to make a fact more or less probable than it would be without the evidence” and (2) “the fact is of consequence in determining the action.” In essence, the revised rule stresses that both conditions must be met in order to deem evidence as relevant.

Digital photographs are commonly admitted as evidence, provided they are relevant for proving or disproving a material fact. There is no requirement for the photographer to testify about the photograph provided a witness with knowledge of the photograph is able to testify that it fairly and accurately represents the depicted scene (Gonzalez 2009). Similarly, satellite images are likely to be deemed relevant and admissible due to their unique ability of providing evidence which satisfies Rule 401 (Crowsey 2002a). The admissibility of satellite images and aerial photographs as evidence is the same as ordinary photographs (Craig 2007). As for GIS evidence, whether in the form of maps, models, or simulations, relevance again

poses a minimal barrier to admission provided consequential facts can be deemed more or less probable via the GIS evidence (Dischinger and Wallace 2005). It would understandably be a waste of time and resources to attempt to introduce irrelevant evidence into a case. Rule 401 therefore should not be considered an obstacle to the admissibility of evidence but rather a mechanism for ensuring an efficient judicial process without adding confusing or ambiguous evidence that provides no supportive assistance in a case.

FRE Rule 402 states that relevant evidence, which meets the criteria for Rule 401 (irrelevant evidence is not admissible), is admissible as evidence unless any of following provides otherwise: (1) the Constitution, (2) a federal statute (e.g., an Act of Congress), (3) the Federal Rules of Evidence, or (4) other rules prescribed by the Supreme Court. Under most circumstances, Rule 402 does not provide a barrier to the admissibility of spatial data. However, Rule 402 does make it clear that there may be circumstances in which relevant evidence cannot be admissible. One clear example would be instances in which national security could be compromised (e.g., a satellite image of a military base). Public safety, privacy, and warrantless searches are the main constitutional issues facing admissibility of spatial data (Markowitz 2002). According to the Fourth Amendment, “the right of the people to be secure in their persons, houses, papers, and effects, against unreasonable searches and seizures, shall not be violated” (US Constitution amend. IV). Three landmark cases decided by the US Supreme Court can be cited as precedent for contesting the admissibility of data derived from geospatial technologies on the basis of constitutional protection guaranteed by the Fourth Amendment (Markowitz 2002). In *Dow Chemical Co. v. United States* (1986), the Supreme Court ruled the use of commercial aerial photography used to search private property did not constitute a search if the private property was observable with the naked eye and therefore the photography was admissible as evidence (Craig 2007). In *Kyllo v. United States* (2001), the Supreme Court ruled the use of a thermal imaging device did require a warrant since the technology revealed details of the interior via technology that was not in the general public use (Craig 2007). However, the Supreme Court did not define “general use” technology, leaving lower courts to rule on a standard (Markowitz 2002). In *United States v. Jones* (2012) 132 S.Ct. 945, the court ruled that the installation of a Global Positioning System (GPS) tracking device on a vehicle and then using the device to monitor the vehicle’s movements constitutes a search under the Fourth Amendment. As such action constitutes a “search,” a warrant must be issued.

Aside from Rule 402 denying the admissibility of evidence, FRE Rule 403 cites additional reasons why evidence may not be admissible in court. Specifically, Rule 403 states that evidence in which the probative value is substantially outweighed by a danger of unfair prejudice, confusing the issues, misleading the jury, undue delay, wasting time, or needlessly presenting cumulative evidence may be excluded. Clearly, photographs and images have the potential to invoke emotion, leading to either favorable or unfavorable prejudice. Similarly, it is not hard to imagine how the use of images could be abused to cause confusion or deceit or how an excess of similar images could be needless. However, as Krouse et al. (2000) pointed out, the interpretation of Rule 403 is highly discretionary when it comes to weighing the probative value against the undesirable affects. Therefore, whether a court allows

or denies the admissibility of evidence on the basis of Rule 403 is strictly at the discretion of individual judges and an uncertainty to be prepared for.

Just as photographs can be seen to cause prejudice, confusion, and misleading testimony, spatial data can also be presented in a manner leading to the same results. For example, the representation of a suspect's home on a map symbolized by a skull and crossbones or a mean-faced emoticon symbol conveys the implication of guilt. Other potential examples could be more subtle, but effective implants of prejudice, confusion, or misleading, such as the choice of color on a map or the use of a map originally intended for a very different purpose. When he wrote "How to Lie with Maps," Monmonier (1996) recognized the fact that maps signified authority and people trusted them unquestioningly, despite the ease of deceitful representation. The reality is that judges, juries, attorneys, plaintiffs, and defendants are part of the population Monmonier suggested would have no reason not to trust a map. However, as Wood has recently reemphasized, "the map is not reality" (Krygier and Wood 2011); therefore, recognition of unfair prejudice or misleading testimony provided through maps may not be evident within the judicial system without the aid of an expert.

Pratt (2001) discussed the potential for CGE to be misleading or prejudicial. CGE is commonly used during the presentation of evidence and in opening and closing arguments to enhance the quality and persuasiveness of the argument. As long as CGE accurately and fairly represents the testimony without being prejudicial or misleading, CGE is admissible to aid in understanding the truth. However, CGE technology has a great potential for promoting prejudice on the part of jurors who often consider CGE to be the truth instead of an aid for understanding the truth. As a heightened sense of reality becomes feasible through CGE technology, such as simulations, 3-D visualization, and virtual reality, the concern for undue prejudice is also increased through the emotions communicated, intentionally or otherwise, to the jurors. In order to minimize the concerns for prejudice and misleading testimony, which may disallow the admissibility of CGE, there are now standard practices in place. First, it should be evident to the court that the CGE is not real. For example, the representation of individuals should not resemble individuals in the courtroom. The more realistic the CGE, the more likely it is to unduly influence jurors. Second, jurors should only be allowed to view CGE, not participate in it. Third, inflammatory sound effects, such as screaming or weapons fire, should be omitted. And finally, the court should request limiting instructions on the jury's consideration of the CGE to make it absolutely clear the CGE is not reality, but rather an illustrative aid for understanding facts.

2.2.2 Rule 611

FRE Rule 611 deals with the mode and order of examining witnesses and presenting evidence. The court is given "reasonable" control over the mode and order of examining witnesses to make the procedures effective for determining the truth, avoid wasting time, and to protect the witnesses from harassment or undue embarrassment. This rule further limits witness cross-examinations and provides guidelines

concerning leading questions during testimony. Spencer (2006) cited Rule 611 as a basis for the exclusion of evidence after it has been admitted into testimony due to the evidence being cumulative of other testimony. Although no explanation was provided, Flamm and Solomon (2004) suggested demonstrative evidence involving the interpretation or manipulation of the underlying data (e.g., animations, simulations, or models) would also fall under Rule 611. Among other terminology, demonstrative evidence introduced under Rule 611 is also known as demonstrative summaries, demonstrative charts, or pedagogical summaries. As such, the purpose is not to provide evidence or summarize voluminous data, but rather to summarize evidence already introduced in a manner intended to persuade a jury into accepting an argument. Demonstrative summaries may be opinions or inferences but are not admissible as evidence, and the court must make it clear to a jury that demonstrative summaries are aids only, not evidence (Levi et al. 2013).

Explaining that the purpose of Rule 611 is to prevent surprise testimony, Delaney and McMahon (2000) recommended showing CGE to opposing counsel before the jury is allowed to see it. The rationale is twofold. First, a witness may use demonstrative evidence to convey an interpreted opinion. Rule 611 is held to a less stringent standard of demonstrative evidence accuracy than Rule 1006 (Levi et al. 2013). However, the use of demonstrative evidence by an expert witness to convey an opinion could unduly influence a jury by being too persuasive or argumentative, but it would still meet Rule 403 standards since there is no probative value. Therefore, the jury should receive instructions to listen to the testimony and regard the demonstrative evidence as an interpretation that has not been subjected to the rigorous standards imposed by Rule 1006.

Second, a witness should be subject to cross-examination. The “surprise” admission of demonstrative evidence by a witness would not allow an opposing council sufficient time to formulate questions for cross-examination. By showing the CGE to the opposing counsel prior to presenting it, any objections or issues can be resolved and avoided. One final consideration more specific to animations and simulations is the fact that they may run uninterrupted (imagine an animation with a long run time) while a witness is on the stand (Delaney and McMahon 2000). Obviously, uninterrupted animations/simulation could have implications on the ability to effectively cross-examine a witness, waste time, or lead to embarrassment if opposing counsel objects to asserted truths. When introducing demonstrative evidence under Rule 611, it must be recognized that the court (i.e., judge) has complete discretion. While some courts could be very liberal in the amount and types of demonstrative evidence, other courts could be very strict.

2.2.3 Rules 702 and 703

Due to the complexity inherent in the nature of geospatial technologies and the evidence they produce, it is probable that an expert witness will be needed to explain and clarify spatial evidence (Markowitz 2002). The issues of opinions and expert testimony are governed by FRE Rules 701–706. Rule 702 allows a qualified expert

to testify in the form of an opinion if four criteria are met: (1) the expert's scientific, technical, or other specialized knowledge will help the trier of fact to understand the evidence or to determine a fact in issue; (2) the testimony is based on sufficient facts or data; (3) the testimony is the product of reliable principles and methods; and (4) the expert has reliably applied the principles and methods to the facts of the case. Furthermore, Rule 702 defines an "expert" witness as a person having knowledge, skills, experience, training, or education qualifying the witness as an expert. Rule 703 is the rule pertaining to the basis of an opinion testimony given by an expert. Amended in the 2011 FRE, Rule 703 now states that "an expert may base an opinion on facts or data in the case that the expert has been made aware of or personally observed." Furthermore, Rule 703 clarifies that "if experts in the particular field would reasonably rely on those kinds of facts or data in forming an opinion on the subject, they need not be admissible for the opinion to be admitted. But if the facts or data would otherwise be inadmissible, the proponent of the opinion may disclose them to the jury only if their probative value in helping the jury evaluate the opinion substantially outweighs their prejudicial effect."

Rules 702 and 703 limit not only the testimony offered by experts but also evidence offered through an expert witness (Spencer 2006). In conjunction with Rule 402, judges serve as "gatekeepers" who apply Rules 702 and 703 to potential testimony to analyze the reliability and relevance of an expert witness (Krouse et al. 2000; Crowsey 2002a; NLECTC 2001). Although Rule 702 does not specify what constitutes "reliable principles and methods," Rule 703 addresses the issue by clarifying the principles and methods should be reasonably relied upon within the experts' particular field (see also Sects. 2.3.1 and 2.3.2 Frye Test and Daubert). While Rule 702 envisioned a relaxed test for admitting scientific, technical, or other specialized knowledge, the "gatekeeper" obligation of judges requires an assessment of the scientific validity of the reasoning or methodology underlying expert testimony to ensure such reasoning or methodology can be properly applied to the facts at issue (NLECTC 2001; Krouse et al. 2000; Crowsey 2002a; Pratt 2001). With respect to CGE, the implications of Rules 702 and 703 are that the qualifications and scientific background of an expert develop into a greater concern than the technology used to surmise facts or opinions (NLECTC 2001). In effect, new and complex methodologies require that an expert not just be a court-qualified expert under Rule 702 but rather a true and recognized expert within the expert's field (Cohen 2008; NLECTC 2001). Based on his extensive experience as an expert witness, Cohen (2008) added that it is the background and experience of the expert witness that are often a decisive factor in determining the outcome of a case.

2.2.4 Rules 802, 803, and 804

FRE Rules 801 through 807 are concerned with hearsay. Defined by Rule 801, hearsay is secondhand information, provided out of court, by someone other than the person testifying in court, which is offered as evidence to prove the truth of the matter

asserted (Cohen 2008; Dischinger and Wallace 2005). Generally, hearsay is not admissible evidence (Rule 802) unless it can be categorized as an exception to the hearsay rule under Rule 803 or Rule 804 (Markowitz 2002; Dischinger and Wallace 2005). Rule 804 is primarily concerned with the admissibility of hearsay evidence when a declarant (the person who made the statement) is unavailable for testimony (e.g., physically or mentally ill). There are six exceptions that allow hearsay to be presented in court under Rule 804 if the conditions of declarant unavailability set forth by Rule 804 are met. Rule 803 allows for 23 exceptions (exception 24 has been transferred to Rule 807) allowing hearsay to become admissible.

Percipient witness (eyewitness) testimony, expert witness testimony, and CGE are each subject to the rule against hearsay. A percipient witness is generally only allowed to provide firsthand knowledge of events without opinions or conjecture (Cohen 2008). However, exceptions to the hearsay rule are available to expert witnesses who may rely on scientific articles and other similar pieces of information not personally known to the expert (Cohen 2008). In conjunction with Rule 703, testimony presented by an expert witness may include hearsay if the basis of the testimony is reasonably relied upon by other members of the expert witness's field of expertise (Crowsey 2002a). When offered in court for the truth of what they assert, CGE, which includes digital spatial data and the products generated from them (e.g., maps and charts), is almost always considered to be out-of-court statements and therefore hearsay (Onsrud 1992; Dischinger and Wallace 2005). Flamm and Solomon (2004) provided a distinction between electronically stored computer data created by humans and data automatically generated by computers, such as the Internet service provider (ISP) log-in or telephone call records. While the evidentiary concerns of automatic data generation by computers raise issues of authenticity and proper functionality, the human-generated electronic data records raise concerns about false and inaccurate out-of-court statements and therefore are considered hearsay. Unless a declarant designed the computer, wrote the software, and generated, manipulated, and stored the computer-generated data end product, an exception to the hearsay rule is needed to qualify the CGE as admissible for proving the truth of the matter asserted (Onsrud 1992).

Assuming CGE is deemed authentic and reliable (based on the discretion of the judge), it may be admissible under the business record or public record hearsay exception (Dischinger and Wallace 2005; Markowitz 2002). Rule 803(6) specifies the criteria necessary to qualify business records as an exception to the hearsay rule and admissible in court. Despite the hearsay nature of spatial data, Rule 803(6) provides that it may be considered reliable and admissible when a qualified witness can testify it was gathered in a routine manner as part of ordinary everyday activities of a business, organization, occupation, or calling (Crowsey 2002a). Furthermore, the data need to be made at or near the time in question by a person with knowledge of the system and not indicate a lack of trustworthiness from either the source of information or the methods or circumstances of preparation. The business record exception is most often applicable to the successful admission of CGE (Onsrud 1992). Rule 803(8) governs the criteria necessary to qualify public records as an exception to the hearsay rule. Public records are simply the records or

statements of a public office. Similar to business records, public records should be properly kept and not indicate a lack of trustworthiness. When a copy of an electronic document submitted for admission comes from files collected and maintained by a public agency and the copy is certified as a correct copy by an authorized person (e.g., custodian of the records), the copy is self-authenticating, and no extrinsic evidence of authenticity is needed (Onsrud 1992). In other words, if the electronic records can be shown to be those provided by a public agency, the records are considered admissible as CGE.

2.2.5 Rules 901 and 902

The previous discussion pertaining to the admissibility of business or public records stipulated that the data needed to be qualified via testimony that the data records were in fact the purported records. Any evidence submitted for admission must be identified sufficiently to satisfy the judge that the evidence is what it is claimed to be. The process of identifying an item of evidence as the purported item is known as authenticating evidence. According to Rule 901, “to satisfy the requirements of authenticating or identifying an item of evidence, the proponent must produce evidence sufficient to support a finding that the item is what the proponent claims it is.”

A nonexclusive list of ten examples for authenticating evidence is provided by Rule 901(b). Among the ten examples, five are relevant to digital data and CGE: (1) testimony by a witness with knowledge, (2) comparison with an authenticated specimen by an expert witness or the trier of fact, (3) distinctive characteristics, (4) evidence about public records, and (5) evidence describing a process or system and showing that it produces an accurate result. Unless authenticity is challenged, *prima facie* evidence (e.g., a declaration of accuracy by a witness) is sufficient for admission under Rule 901 (Barakat and Miller 2004). In other words, the threshold of authenticity is relatively low. The requirement is that the evidence could be authentic, not that the evidence is proven to be truly authentic. However, in the event authenticity is challenged, a proponent must be prepared to conclusively prove it is what is claimed. Rule 902 stipulates certain forms of evidence are self-authenticating. Twelve items are listed with provisions attached. Depending on their creation and publication, most of the 12 items could be relevant to paper maps (Markowitz 2002). Although CGE may be self-authenticating, CGE is much more likely to be challenged unless printouts are certified as correct copies by a custodian of the records (Onsrud 1992).

Unless considered self-authenticating by Rule 902, the extrinsic authentication standard of Rule 901 applies to all items introduced as evidence. Although spatial data and CGE have unusual characteristics, authentication problems are similar to those encountered by any other computer records (Onsrud 1992; Flamm and Solomon 2004). One major challenge to authenticating evidence from digital data is establishing accuracy and reliability of results from the process or system producing the data. Proper authentication requires that reliability of computer processes and accuracy of results be subject to scrutiny (State of Connecticut v. Alfred Swinton 2004).

A particularly significant issue involved in establishing accuracy and reliability to support a finding that an item of evidence is what the proponent claims it is involves establishing a chain of custody (Pratt 2001). Whether evidence is physical or digital, establishing a chain of command is essential if tampering is alleged. While physical evidence should be accompanied by a required chain of custody form that documents custody, control, transfers, analyses, or disposition of each item, digital data may not have a chain of custody form. If the originality of evidence is questioned, each and every custodian may be required to testify to the integrity of the evidence during their possession if authentication cannot be provided otherwise by Rule 901(b) (Cohen 2008). Although digital data is highly susceptible to tampering (e.g., alteration of digital photos), another concern is errors generated during collection, storage/management, analyses, manipulation, or presentation. In order to establish a chain of custody for digital data, the proponent must show (1) the accuracy and reliability of the original source data to include all assumptions, formulas, and calculations used in defining and analyzing the data; (2) the accuracy of the source data entered into the computer; (3) the reliability and capability of the hardware and software used; (4) the process of software used for the computer graphics; (5) the methods used to produce the graphics in court; and (6) the accuracy and reliability of the final presentation (Crowsey 2002a; Krouse et al. 2000; Dischinger and Wallace 2005). Crowsey (2002a) recommended testimony by expert witnesses who could reliably authenticate the accuracy and reliability of digital data to establish a chain of custody.

Citing three previous landmark cases, the Connecticut Supreme Court (*State of Connecticut v. Alfred Swinton* 2004) established legal precedent for authenticating CGE (NDAA 2004). The court opined that there must be “testimony by a person with some degree of computer expertise, who has sufficient knowledge to be examined and cross-examined about the functioning of the computer.” Stating that the salient issue was not only the reliability of the evidence, but also the reliability of the procedures involved, the court decided that the opposing counsel must have the opportunity to cross-examine a witness as to the methods used. The court noted that reliability issues may arise through or in (1) the underlying information, (2) the entering of information into a computer, (3) the computer hardware, (4) the computer software, (5) the execution of instructions which transforms information, (6) the output, (7) the security system used to control access to the computer, and (8) the user errors which may arise at any stage. Addressing reliability of computers, the court adopted six factors to be used as guidelines for authenticating CGE evidence: (1) the computer equipment is accepted in the field as standard and competent and was in good working order; (2) qualified computer operators were employed; (3) proper procedures were followed in connection with the input and output of information; (4) a reliable software program was utilized; (5) the equipment was programmed and operated correctly; and (6) the exhibit is properly identified as the output in question. Furthermore, the court opined there should be no distinction between various CGE. Animations and simulations should be held to the same stringent standards of reliability despite claims that animations are illustrative in nature while simulations provide substantive evidence.

2.2.6 Rule 1006

The two potential avenues for admitting CGE derived from spatial data are as scientific evidence under Rules 702 and 703 or as demonstrative evidence under Rule 1006 (Crowsey 2002a; Krouse et al. 2000). Demonstrative evidence used to clarify or illustrate complex information is allowed under Rule 1006. According to Rule 1006, summaries, charts, or calculations to prove the content of voluminous writings, recordings, or photographs that cannot be conveniently examined in court can be used, provided the originals or duplicates are available for examination. Demonstrative evidence is essential for successful litigation since juries expect it and it appeals to the five senses (Marks 2003). Although demonstrative evidence has no probative value and cannot be examined during jury deliberation, it is frequently and opportunistically used as a persuasive aid in keeping a jury interested and focused on what is being presented during trial (Gonzalez 2009).

Demonstrative evidence is subject to FRE tests for admissibility governed mainly by Rules 401–403 and 901 or 902. Accordingly, demonstrative evidence must be relevant (Rule 401), admissible (Rule 402), fair (Rule 403), and authenticated (Rule 901) or self-authenticating (Rule 902), regardless of whether or not it is CGE (Pratt 2001). Flamm and Solomon (2004) recommended pretrial disclosure of the intended use of demonstrative evidence to the courts and opposing council to hasten proceedings with regard to evidentiary standards of relevance, fairness, admissibility, and authentication. Crowsey (2003) constructed a pretrial disclosure checklist exclusive to geospatial technologies to avoid oversight as well to as identify potential weaknesses that would result in exclusion of exhibits. Conversely, Pratt (2001) discussed numerous potential reasons to object to the inclusion of demonstrative evidence in general, and CGE in specific, by an opposing council. Ultimately, the admissibility of demonstrative evidence is left to the sound discretion of the trial judge (Spencer 2006).

2.3 Additional Considerations

This section discusses additional evidentiary considerations that may apply to geospatial data. In practice, several legal tests control admission of evidence in the United States (Markowitz 2002). The FRE have already been discussed as the rules of admissibility adopted by the US Supreme Court which apply to all federal courts in order to ascertain the truth and secure a just determination from proceedings. Federal courts must also adhere to the US Constitution, which is the supreme law within the United States. Following the rules set forth within the US Constitution also requires following constitutional law, which are the interpretations defining the scope and application of the Constitution. An additional legal test of admissibility used by federal courts is known as the Daubert standard. Unlike the FRE, which are a defined set of rules governing numerous topics, the Daubert standard is derived from a court case decided by the US Supreme Court in which Rule 104 was reviewed

to interpret Rule 702. Prior to the Daubert standard, the Frye test was used by federal courts. Many state courts today still apply the Frye test as a means of testing the admissibility of evidence.

Furthermore, Cheng and Yoon (2005) cited research suggesting that in practice, Daubert courts essentially still perform what is considered a Frye test. Since the Frye test was originally a federal test, it remains the basis of the Daubert standard, is still used by state courts, is prominent in the literature, and is applicable to spatial data. On these grounds, it must be recognized as an important consideration for further discussion. After reviewing the Frye test and Daubert standard, this section will discuss the pictorial testimony and silent witness theories which govern the admissibility of digital photographs and video.

At this point, it would be prudent to recognize the considerations discussed within this section are not the only additional considerations regarding the admissibility of evidence. There are many further considerations relevant to the admissibility of evidence. For example, the previous discussion of the FRE already explained chain of custody issues. While some additional considerations have already been discussed elsewhere, identifying and discussing all possible considerations are well beyond the scope of this chapter.

2.3.1 Frye Test

As science advanced, the legal system attempted to develop coherent tests that could be applied to scientific evidence (Committee on Identifying the Needs of the Forensic Sciences Community 2009). The first notable development occurred with a landmark decision in 1923 that ruled scientific evidence needed to be “generally accepted.” Scientific evidence interpreted by a court as “generally accepted” by a meaningful segment of the associated scientific community meets the requirements of the Frye test (Cheng and Yoon 2005). This standard comes from the case *Frye v. United States*. The Frye test applies to procedures, principles, or techniques that may be presented in the proceedings of a court case and is still the *de jure* standard in several states.

The Frye test emerged from a murder appeal in which a lie detector was used. Expert witnesses elaborated on scientific experiments which revealed an increase in blood pressure when someone lied, concealed facts, or was guilty of a crime. The proffered theory was that the truth was a spontaneous event while a deception was an intentional event, which could be identified through an increase in blood pressure. Although the court conceded difficulty in establishing when a scientific principal advances from the experimental stage to the demonstrable stage, it was ruled that scientific recognition and acceptance was necessary for the admissibility of expert testimony (*Frye v. United States* 1923). Simply stated, the court must determine if an expert’s testimony is based on recognized and accepted science. The acceptance of science within the associated community, also known as the scientific validity, emerged as a legal test referred to as the Frye test. Despite the modern significance,

the Frye case went unnoticed for decades (Faigman et al. 2006). No other court cases cited Frye, and no law review articles discussed Frye until the 1970s and the release of the first version of the FRE.

It should be noted that the Frye test specifically addressed the underlying principles and methods used by experts to form an opinion. Courts and commentators found the general acceptance test to have significant limitations, particularly the vagueness of its conditions (see Faigman et al. 2006 for criticisms of Frye). The underlying methods were required to be scientifically valid; however, the Frye test did not require the opinion of the expert to be generally accepted by the scientific community (Committee on Identifying the Needs of the Forensic Sciences Community 2009). The issue of whether or not an expert opinion needed to be generally accepted within the expert's field was later decided in *Berry v. CSX Transportation, Inc.* (1998) when the court ruled that as long as the opinion was based on scientific validity, it was not necessary for the opinion to be generally accepted.

2.3.2 *Daubert*

After the FRE were first enacted in 1975, many people wondered whether or not the Frye test had become obsolete (NLECTC 2001). The first version of Rule 702 provided that the mere "assistance" to the trier of fact appeared as the touchstone of admissibility. Litigants, judges, and scholars were uncertain if Rule 702 embraced the Frye test or established a new standard (Committee on Identifying the Needs of Forensic Sciences Community 2009). The Supreme Court ruling in the case of *Daubert v. Merrell Dow Pharmaceuticals, Inc.* (1992) clarified the ambiguity between Rule 702 and the Frye test by adopting a new framework for evaluating the reliability of scientific evidence (Committee on Identifying the Needs of the Forensic Sciences Community 2009; NLECTC 2001; Cheng and Yoon 2005).

In *Daubert*, the Supreme Court held that Rule 702, not the Frye test, controlled the admission of expert testimony in federal courts. Noting Rule 702 made no mention of the Frye test, the *Daubert* court ruling provided judges with guidance in a newly established role of "gatekeepers" of scientific evidence (NLECTC 2001; Committee on Identifying the Needs of the Forensic Sciences Community 2009). The *Daubert* standard set forth that "any and all scientific testimony or evidence admitted is not only relevant, but reliable" (*Daubert v. Merrell Dow Pharmaceuticals, Inc.* 1992). This "gatekeeper" approach had judges analyzing the relevance and reliability of potential testimony (NLECTC 2001). While relevance was determined from Rule 104(b), reliability was to be based on four considerations interpreted in the context of each case: (1) falsifiability, (2) peer review, (3) error rates, and (4) acceptability in the relevant scientific community (Cheng and Yoon 2005; NLECTC 2001; Farber 2008). The falsifiability consideration allowed judges to consider whether a theory or technique could be, or had been, tested. The peer review consideration allowed judges to examine whether a theory or technique was subjected to peer review and publication. Error rates considered the known or potential rate of error of a particular

scientific technique, while considerations of acceptability examined whether the theory or technique had gained general acceptance in the relevant scientific discipline.

Essentially, the Daubert ruling required expert testimony pertain to “scientific knowledge” to establish a standard of “evidentiary reliability” (Committee on Identifying the Needs of the Forensic Sciences Community 2009). More importantly, judges gained a new role as “gatekeepers” and were provided with guidance for performing a preliminary assessment of whether the methodology or reason underlying testimony was scientifically valid and whether that methodology or reasoning could properly be applied to the facts at issue (NLECTC 2001; Cheng and Yoon 2005). As Faigman et al. (2006) noted, the specific responsibility of judges to evaluate scientific validity obligated them to become much more familiar with the methods and culture of science that they had been insulated from during the scientific revolution. Indeed, the process of admitting or denying expert opinion meant judges needed to adequately demonstrate, on record, that they performed their role as “gatekeeper” by demonstrating a sufficient appreciation of the scientific method.

Since Daubert, the Supreme Court has broadened and strengthened the gatekeeping role of the trial judge (Cheng and Yoon 2005). In 2000, FRE Rule 702 was amended in response to Daubert and two related cases that collectively became known as the Daubert trilogy. The Daubert trilogy refers to three Supreme Court cases that articulated the Daubert standard. In addition to Daubert v. Merrell Dow, the cases of General Electric Co. v. Joiner (1997) and Kumho Tire Co. v. Carmichael (1999) set new precedent leading to the amending of Rule 702. GE v. Joiner reaffirmed the role of a trial judge as “gatekeeper” in determining whether an expert’s opinion was both relevant and reliable. The district court determined expert testimony linking polychlorinated biphenyls (PCBs) to cancer was too speculative since it was not based on a single study, but rather on several dissimilar studies. Due to the analytical gap between the data and proffered opinion, the Supreme Court ruled the district court did not abuse its discretion and was fully capable of deciding whether to admit or dismiss causal evidence. Kumho Tire v. Carmichael involved a case relying upon an expert who was not a scientist. The matter before the Supreme Court was to decide how Daubert applied to testimony by engineers and other experts who were not scientists. It was ruled that the Daubert standard was flexible and therefore extended a judges “gatekeeping” obligation to testimony based on “technical” and “other specialized knowledge.”

Based on the Daubert standard and the requirements for admissibility under the FRE, the introduction of geospatial technologies and the derived spatial data will most likely need to be elucidated via expert testimony (Dischinger and Wallace 2005; Markowitz 2002). The 2009 US Supreme Court ruling in Melendez-Diaz v. Massachusetts (2009) currently requires forensic scientists to testify under the confrontational clause if a defendant objects to the admission of evidence without the forensic scientist available for live testimony. The premise of the confrontational clause is that a defendant has the right to face an accuser under the Sixth Amendment. The Supreme Court opined reports and affidavits were insufficient for admission by prosecutors without an expert witness available during trial for cross-examination. Although the ruling did not extend beyond forensic experts, it also did not define a

forensic expert or explicitly limit live testimony requirements to forensic experts. As a result, substantive evidence should always be accompanied by an expert witness subject to Rule 702 and the Daubert standard (Pratt 2001). Although testifying as an expert witness may seem daunting, several helpful documents are available. Cohen (2008) provided a thorough description of expectations and requirements applicable to any expert witness. Wells (2012) provided tips and resources for forensic science experts pursuant to *Melendez-Diaz v. Massachusetts*. Additionally, Dischinger and Wallace (2005) discussed the qualifications and the capacity of GIS experts to testify.

2.3.3 “Pictorial Testimony” and “Silent Witness” Theories

Photographs constitute one of the most common types of evidence in court (Pratt 2001); however, the admissibility and reliability of digital photographs have often been challenged. (Barakat and Miller 2004). Initially, the quality of digital photos was an issue due to the inferior quality compared with traditional photographs. Over time, the quality improved and the focus has shifted to the potential for manipulation. Rule 901 provides that evidence must be authenticated as a true and accurate representation through one of the means listed in Rule 901(b). The most common means for authenticating a digital photograph is through the testimony of a witness. This witness testimony is referred to as the “pictorial testimony” theory (Barakat and Miller 2004). If a judge is sufficiently satisfied that the photograph is relevant to the case and a fair and accurate representation of what is claimed by the witness testimony, then it is admissible under the pictorial testimony theory. Once admitted into evidence, it is then up to the opposing counsel to challenge the authenticity and expose any alterations during witness cross-examination (Barakat and Miller 2004).

In some circumstances, digital photographs have no witness to testify as to the accuracy. For example, digital photographs and video captured by surveillance devices, such as CCTV, are often useful for capturing an offense being committed. Without the testimony of a witness during trial, there is no way to cross-examine a witness and challenge the contents’ accuracy. However, since the digital photograph or video may be relevant or even critical, courts have ascribed to the “silent witness” theory which allows the digital photograph or video to “speak for itself” (Barakat and Miller 2004). Under the “silent witness” theory, proof of surrounding circumstances is considered sufficient to find the photographic evidence a fair and accurate representation of fact. Unlike the “pictorial testimony” theory, the “silent witness” theory considers several factors to determine reliability and accuracy. These factors include (1) evidence establishing the date and time of the photographic evidence; (2) any evidence of tampering or editing; (3) accuracy and reliability of the photographic evidence as it relates to the operational condition and capability of the equipment; (4) procedures employed in preparing, testing, operating, and securing the photographic evidence; and (5) testimony identifying the relevant participants captured in the photographic evidence (Barakat and Miller 2004). Recognizing the necessity of

imposing adequate safeguards against manipulation and tampering, the courts impose a burden upon the offering party of the photographic evidence to prove authenticity above and beyond the requirements of the “pictorial testimony” theory.

Digital photographic evidence may be admitted as either demonstrative evidence, pursuant to the “pictorial testimony” theory, or as substantive evidence pursuant to the “silent witness” theory (Pratt 2001). Manipulations and alterations of digital photographic evidence represent a major concern, especially when there is no witness to testify about the authenticity. Barakat and Miller (2004) warn that digital photographic evidence will be subject to significant cross-examination, particularly in regard to chain of custody issues. Once the digital photographic evidence is collected, it should be documented carefully and all changes logged to support authenticity of the digital evidence. The proffering party should be prepared to prove the digital photographic evidence is unedited. In the case of image enhancements, each step must be documented and repeatable from a copy of the original.

2.4 Summary

In today’s society, computer technology is used not only to commit crimes but also in litigation (Pratt 2001). From the most basic use (e.g., drafting a motion) to more advanced uses (e.g., producing digital photographs and maps) through the most sophisticated uses (e.g., creating animations, simulations, and virtual reality), it is rare to discover a case that does not involve the use of computers. While remaining cautious about the trustworthiness and reliability of CGE, judges at all levels of the judicial hierarchy have demonstrated an increased comfort level with CGE use (Flamm and Solomon 2004). However, it is clear from a pragmatic legal perspective that CGE differs immensely from traditional paper documents (Onsrud 1992). It is also clear, at least for now, there are no special rules governing the use and admissibility of CGE in court (Pratt 2001). The most recent revision to the FRE makes only two references to computer data: Rules 901(b)(9) and 1001(3). As this chapter has pointed out, the FRE have proven flexible enough to cover the use and admission of CGE in the same manner as they would use traditional paper exhibits. Referring specifically to geospatial technologies, Foote and Lynch (2000) acknowledge that if GIS could not be used to prove legal cases, it would lose much of its value to the forensics system. This chapter has also identified several issues which have complicated the admissibility of CGE (e.g., authenticity) and the FRE requirements (e.g., relevance and reliability) and tests (e.g., Daubert trilogy) necessary to satisfy a judge that any CGE evidence is what it is claimed to be. However, the combinations of rules and tests have thus far helped to establish a more precise test for scientific testimony that does not focus so much on technology as it does the qualification and background of an expert witness (NLECTC 2001).

The goal of this chapter has been to provide a source of generalized information that can be used as a guide for a more thorough examination of specific issues related to admissibility of geospatial technologies. Most of the information has been

collected from scholarly articles from diverse journals and disciplines. Scholars and practitioners are only now beginning to publish books about the legal aspects of spatial data and technologies. For a further in-depth discussion on the admissibility of scientific evidence, see Faigman et al. (Faigman et al. 2006). Cho (2005, 2012) has provided comprehensive information specific to GIS legal issues, while Janssen and Crompvoets (2012) addressed geographic data. Additionally, Ito (2011) exclusively discussed the legal issues of satellite remote sensing.

References

- Barakat B, Miller B (2004) Authentication of digital photographs under the “pictorial testimony” theory: a response to critics. *Fla Bar J* 78(7):38–43
- Berry v. CSX Transportation, Inc (1998) 709 So. 2d 552 (Fla. 1st DCA 1998)
- Bird S (2001) Scientific certainty: research versus forensic perspectives. *J Forensic Sci* 46(4):978–981
- Cheng EK, Yoon AH (2005) Does Frye or Daubert matter? A study of scientific admissibility standards. *Va Law Rev* 91(2):471–513. doi:10.2307/3649430
- Cho G (2005) Geographic information science: mastering the legal issues. Katholieke University, Leuven
- Cho G (2012) Geographic data and legal liability issues. In: Janssen K (ed) Legal aspects of geographic data and spatial data infrastructures. Katholik University, Leuven, pp 153–166
- Cohen KS (2008) Expert witnessing and scientific testimony: surviving in the courtroom. CRC Press, Boca Raton
- Committee on Identifying the Needs of the Forensic Sciences Community (2009) Strengthening forensic science in the United States: a path forward. The National Academies Press, Washington, DC
- Craig BJ (2007) Online satellite and aerial images: issues and analysis. [Minnesota Legal Studies Research Paper No. 08–11]. *N. D. Law Rev* 83:547–578
- Crowsey R (2002a) A legal assistant’s guide to legal applications of geospatial information. <http://www.crowsey.com/pdf/spatialInformation.pdf>. Accessed 30 Sept 2008
- Crowsey R (2002b) Using spatial information. <http://www.crowsey.com/pdf/litigatorsGuide.pdf>. Accessed 30 Sept 2008
- Crowsey R (2003) Geographic intelligence risk reduction checklist. <http://www.crowsey.com/pdf/CheckList.pdf>. Accessed 20 Jan 2009
- Daubert v. Merrell Dow Pharmaceuticals, Inc (1992) 509 U.S. 579, 113 S.Ct. 2786
- Delaney TQ, McMahon CM (2000) Jumping over the evidence hurdle at trial. *Natl Law J*. http://www.brinksgilson.com/news_events/index.php?action=view&publication_id=116. Accessed 28 Aug 2013
- Dischinger SS, Wallace LA (2005) Geographic information systems: coming to a courtroom near you. *Colo Lawyer* 34(4):11–23
- Dow Chemical Company v. United States (1986) 476 U.S. 227
- Faigman DL, Saks MJ, Sanders J (eds) (2006) Admissibility of scientific evidence. In: Modern scientific evidence: the law and science of expert testimony, vol 1. West Pub Co, Eagan, pp 1–124
- Farber DA (2008) Harnessing the power of information for the next generation of environmental law: II Use and abuse of information: modeling climate change and its impacts: law, policy, and science. *Tex Law Rev* 86:1655
- Fiedler BS (2003) Are your eyes deceiving you?: the evidentiary crisis regarding the admissibility of computer generated evidence. *NY Law Sch Law Rev* 48:295–321
- Flamm S, Solomon SH (2004) Admissibility of digital exhibits in litigation. In: Samuel C, Solomon H (eds) Lynbrook. DOAR Litigation Consulting, New York

- Flanagan DC, Ascough JC, Nearing MA, Laflen JM (2001) The Water Erosion Prediction Project (WEPP) model. In: Harmon RS, Doe WW III (eds) *Landscape erosion and evolution modeling*. Springer, Dordrecht, pp 145–199
- Foot KE, Lynch M (2000) Legal issues relating to GIS. *The geographer's craft*. University of Colorado at Boulder, Boulder
- Frye v. United States (1923) 293 F. 1013, 1014 (D.C., Cir 1923)
- General Electric Co. et al. v. Joiner et ux (1997) 522 U.S. 136, 118 S. Ct. 512, 139 L. Ed. 2d 508
- Gonzalez EA (2009) Advanced trial handbook – demonstrative evidence. <http://www.caught.net/prose/advtt/hbdemons.htm>. Accessed 14 Jan 2009
- Hemmens C, Cooper J, Hatch V (2007) Law enforcement case law. *Crim Justice Rev* 32(3):303–328. doi:10.1177/0734016807304917
- Ito A (2011) *Legal aspects of satellite remote sensing*. Martinus Nijhoff Publishers, Boston
- Janssen K, Crompvoets J (eds) (2012) *Geographic data and the law – defining new challenges*. Leuven University Press, Leuven
- Krouse AJ, Ferry MM, Crowsey RC (2000) Satellite imagery: the space odyssey arrives in the courtroom. <http://www.crowsey.com/pdf/spaceOdyssey.pdf>. Accessed 30 Sept 2008
- Krygier J, Wood D (2011) *Making maps: a visual guide to map design for GIS*. Guilford Press, New York
- Kumho Tire Company, Ltd. v. Carmichael (1999) 526 U.S. 137, 119 S.Ct. 1167
- Kyllo v. United States (2001) 533 U.S. 27
- Levi DF, Nowinski PA, Killefer G (2013) Federal trial objections, revision 7. James Pub., Inc., Costa Mesa
- Markowitz KJ (2002) Legal challenges and market rewards to the use and acceptance of remote sensing and digital information as evidence. *Duke Environ Law Policy Forum* 12(2):219–264
- Marks SC (2003) The admissibility and use of demonstrative aids. *The Brief* 32:4
- Melendez-Diaz v. Massachusetts (2009) 557 U.S. 305
- Monmonier MS (1996) *How to lie with maps*. University Of Chicago Press, Chicago
- NDAA (2004) Connecticut Supreme Court issues new standard for computer-generated evidence. *Update Express*, May
- NLECTC (2001) Technology goes to court. *TechBeat* (Spring)
- Onsrud HJ (1992) Evidence generated from GIS. *GIS Law* 1(3):1–9
- Pratt FH (2001) The use of computer-generated exhibits in federal criminal cases. *Defender Services Division Training Branch*, Washington, DC
- Spencer EL (2006) Use and misuse of technical data telling the scientific story to scientific virgins. In: American Law Institute – American Bar Association Continuing Legal Education ALI-ABA Course of Study, pp 1–9. <http://www.grahamdunn.com/go/articles/use-and-misuse-of-technical-data-telling-the-scientific-story-to-scientific-virgins>. Accessed 26 Feb 2009
- State of Connecticut v. Alfred Swinton (2004) 268 Conn. 781; 847 A.2d 921
- US Constitution. Amendment IV
- United States v. Jones (2012) 132 S.Ct. 945
- Wells D (2012) In brief: Law 101: legal guide for the forensic expert. *NIJ J* (269):24–25. <http://www.nij.gov/nij/journals/269/inbrief.htm>. Accessed 23 Apr 2012

Forensic GIS

The Role of Geospatial Technologies for Investigating
Crime and Providing Evidence

Elmes, G.A.; Roedl, G.; Conley, J. (Eds.)

2014, X, 310 p. 91 illus., 67 illus. in color., Hardcover

ISBN: 978-94-017-8756-7