Geospatial Evidence in International Human Rights Litigation

Technical and Legal Considerations

AAAS
Scientific Responsibility, Human Rights and Law
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<td>American Association for the Advancement of Science</td>
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<td>ECCC</td>
<td>Extraordinary Chambers in the Courts of Cambodia</td>
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<td>FAFG</td>
<td>Guatemalan Forensic Anthropology Foundation</td>
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<td>Geographic Information Systems</td>
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<td>NGO</td>
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<td>NOAA</td>
<td>National Oceanic and Atmospheric Administration (U.S.)</td>
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<td>SFTP</td>
<td>Secure File Transfer Protocol</td>
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<td>VGI</td>
<td>Volunteered Geographic Information</td>
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1. Introduction

Geospatial technologies have become an important source of evidence in international criminal prosecutions, as well as other types of human rights litigation and advocacy.\(^1\) Civilian high-resolution remote sensing satellites have been available since 1999 and have been used for human rights documentation since at least 2000.\(^2\) Yet, to realize the full potential that geospatial technologies can offer for documenting violations and holding perpetrators accountable requires that human rights advocates, investigators, litigators, and judges understand geospatial technologies, the scientific methods involved in analyzing geospatial data, the inherent limitations of these systems and data, and how best to apply evidentiary standards to the evaluation of scientific evidence.

Since its inaugural session in 2003, the International Criminal Court has had 26 cases before it and has issued verdicts in six cases. These numbers reflect the enormously difficult task of proving beyond a reasonable doubt that a defendant is individually responsible for mass atrocities and war crimes. A common complication is the burden of proving widespread, systematic patterns of human rights violations repeated over time, documentation of which is difficult using traditional methods. The trials often focus on incidents that took place during conflicts, when investigators could not access the locations because of danger or remoteness.

Remotely sensed data offer solutions to some of these most difficult human rights documentation challenges. They can illustrate patterns of attacks over a sprawling region, demonstrate destruction, new construction, or military movements in otherwise inaccessible areas, reveal the date and manner in which important cultural resources were demolished or forests were cut down, and provide a baseline and cross-check to knit together witness testimony, online photos and videos, and any other evidence that has a spatial component. Satellite images taken over weeks, months, or years can illustrate changes imperceptible to witnesses on the ground and can do so with time, date, and location tags to help assure their veracity. They can corroborate witness testimony, as well as digital evidence such as photographs and videos.

Geographic Information Systems (GIS) also offer the potential for highly sophisticated analyses. For example, by creating images that incorporate multiple wavelengths of the electromagnetic spectrum, some of which are invisible to humans, it is possible to create false-color composite images. This technique, known as multispectral imaging, is capable of revealing information, such as vegetation stress, that is invisible to the human eye. Data acquired at even longer infrared wavelengths are capable of detecting the thermal emissions of high-temperature objects such as fires, while radar imagery can provide


information about the size, shape, and orientation of surfaces at human scale. Because the data that make up these images are digital, they can be analyzed mathematically in GIS software to reveal spatial and temporal patterns that even the most skilled analyst would be unable to discern visually. At the cutting edge of these techniques is machine learning, which enables computers to parse large datasets and identify patterns that are often understood intuitively by humans but are difficult to define using rigid mathematical definitions.

For over a decade, the American Association for the Advancement of Science (AAAS) has conducted geospatial analysis in a human rights context, through which it has amassed significant expertise in using these tools for human rights documentation and evidence gathering. AAAS analysis has been cited in both scholarly and popular publications, and its experts have testified before international tribunals and conducted trainings for courts and commissions from Africa to Europe to the Americas. Through its efforts, AAAS has created opportunities, grappled with challenges, developed procedures and identified best practices for the analysis and presentation of evidence generated by geospatial technologies in litigation.

This report draws from this experience and lessons learned by AAAS. It is intended to provide a starting point for human rights advocates who are considering using geospatial technologies in their human rights documentation efforts, as well as recommendations to ensure the most rigorous scientific methods and robust analysis guide the admission of this evidence in courts. The report begins with an introduction to geospatial technologies and examples of the contexts in which AAAS has applied geospatial technologies to the documentation of human rights concerns. The subsequent section describes the human rights cases in which international courts have relied on geospatial evidence, and the standards they used to evaluate the evidence. This review highlights the emerging recognition by courts that satellite imagery, as part of a rigorous geospatial analysis, can be much more than simple photographic evidence, and such imagery must be entered through the testimony of an expert witness. Because most international criminal courts have not developed settled practices for expert witnesses in this field, a section of the report describes the Daubert principles developed by courts in the United States and later adapted in other countries to review and assess scientific evidence and expert witnesses. Finally, the report makes recommendations for jurists, human rights organizations, governments, and private suppliers of image data, to ensure that the courts are presented with, and have procedures in place to properly assess and weigh, rigorous and scientifically sound geospatial evidence.

Documentation with geospatial technologies that does not meet the thresholds for international criminal prosecutors – which must prove the individual defendant guilty beyond a reasonable doubt – can still be very useful for other types of human rights litigation. As described in this report, these include actions in national or regional courts to establish indigenous land rights or actions by displaced persons seeking redress for forced
evictions. Geospatial technologies are also used in advocacy campaigns calling for legal reforms and for corporate accountability for human rights violations. This report intends to support these efforts as well. By focusing on the most stringent threshold, the recommendations of this report should be useful to a wide range of human rights efforts.
2. Overview of Geospatial Technologies for Human Rights Documentation

Geospatial technologies encompass a broad range of tools for the collection, management, presentation, and analysis of location-based (or geographic) data, defined as information that contains or is associated with position. Any information that incorporates explicit geographic location into its structure comes within this definition; the subject matter of the data is immaterial. As a result of this broad scope, geospatial technologies can be used by professionals in a variety of fields from climatology, ecology, and geography to public health, urban planning, human rights, and humanitarian response. Geospatial technologies can be used at any spatial scale, from documenting excavations of individual graves of “disappeared” persons to monitoring global climate change, as well as any temporal scale, from monitoring intra-day variations in environmental pollution to sea ice retreat over decades. For those unfamiliar with geospatial technologies, the Appendix provides examples and descriptions of some of the various technologies and analysis techniques.

How are geospatial technologies useful for human rights documentation?

Geospatial technologies have enormous potential for and have found significant application in human rights documentation.\(^3\) By using satellite remote sensing, for example, analysts can generate data about events in areas that are inaccessible to ground-based investigators due to legal, logistical, or security reasons. Examples of this type of application include investigations into villages being burned in Darfur,\(^4\) and the shelling of areas designated for civilians in Sri Lanka.\(^5\) They can also be used to document environmental crimes, such as the impact of oil spills on communities in Nigeria,\(^6\) and violations of cultural rights, for example, the destruction of mosques and ancient monuments in Syria and Iraq.\(^7\)

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The village of Nejaha, South Darfur, before (left) and after (right) a reported attack in 2010. Remote sensing provides investigators with access to areas that were formerly off-limits. (Images: DigitalGlobe)

When conducting fieldwork on the ground, data from global navigation satellite systems (GNSS), such as Global Positioning Systems (GPS), often serve as the foundation for other forms of data collection, by ensuring that all records are associated with the location at which they were collected. For example, human rights workers collecting eyewitness reports on living conditions in a particular neighborhood may use GPS-provided metadata to enable the survey responses to be searchable by location. By mapping these responses using GIS, certain patterns may become apparent that would not be obvious from the individual reports. The inclusion of GPS metadata would enable analysis of the dataset using spatial statistics, which has the potential to reveal trends otherwise difficult to detect, such as a relationship between proximity to particular water sources and rates of infectious disease. By taking advantage of volunteered geographic information (VGI), in certain situations these types of analyses may even be conducted without human rights workers or geographers collecting data in the field at all. In such cases, however, special attention must be paid to any biases or quality issues that may be present in this type of volunteered data.

Because civilian high-resolution remote sensing satellites have existed only since 1999, the study of small-scale phenomena that took place earlier than this must rely on declassified government imagery. These records often do not exist in digital form, and must be accessed on physical film at specialized archival facilities. After these images have been digitized with a scanner or other device, and georeferenced, they can provide researchers with a valuable layer of information to incorporate into their GIS system. One recent example of this has been the study of clandestine burials in Guatemala, where disturbances in the soil have been observed in images from the early 1980s in areas that correspond to eyewitness reports of burials reported by the Guatemalan Forensic Anthropology Foundation (FAFG). Subsequent travel to these sites for “ground-truthing” has the potential to add significantly to the amount of information available about the victims of that country’s civil war.

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8 Civilian low-resolution sensors have existed since the 1970s. As such, the study of large-scale phenomena, such as land-cover change, are not subject to this restriction.
Declassified imagery from the 1980s shows disturbed soil (red polygons) on a Guatemalan military base near areas where eyewitness testimony indicates the presence of mass graves. (Image: NARA)

Beyond satellite image analysis, other types of geospatial technologies can also help establish ground truth in human rights investigations. For example, 3-D mapping of gravesites using laser scanning or photogrammetry can be used to create detailed models of exhumed remains, preserving the quantitative contextual relationships between skeletons. This is the case even when the remains of victims are exhumed one at a time. By making spatially referenced models of each individual skeleton in the grave as it is uncovered, merging these models, and removing irrelevant objects like dirt or debris, a composite scene can be created that enables investigators to visualize all bodies in the grave at once, and from any perspective. These types of models, which cannot be created using traditional photographic methods, are a potentially powerful tool for visualizing evidence.

**Limitations**

Potential sources for geospatial data include governments, international organizations such as the United Nations, private-sector entities, and non-governmental organizations (NGOs). The limitations of data from these sources, both fundamental and situational, are also diverse. For example, financial constraints may force NGOs to limit the scope of research, private companies may offer data only for areas where there is sufficient market demand, and governments may restrict the scope of their data releases due to national security concerns.

No matter what source of data is chosen for a given project, an awareness of the information’s limitations is critical to a successful outcome. Some specific limitations
associated with geospatial information – remote sensing in particular – include (1) coverage and resolution; (2) government restrictions; (3) ethical considerations; and (4) cost. These limitations are described in more detail below.

Coverage and resolution

Satellites owned by private companies collect most civilian high-resolution satellite imagery. Because these satellites are constrained by downlink bandwidth and onboard storage capacity, their operators must prioritize when and where images are acquired according to predictions of customer demand. Often, this results in significant coverage over certain areas of the globe and more limited coverage elsewhere. In some cases, imagery may also be acquired at the request of a customer who has purchased exclusive rights to that data. In these cases, the images will not be present in the archives of the original vendor, although in some cases the holder of the rights is themselves a third-party re-seller of data, from whom the images can be purchased in a separate transaction.

Lower-resolution imagery often allows for greater geographic coverage, and is extremely useful for the documentation of events that are spread across a wide area, such as changes in land use, or environmental monitoring. The amount of detail visible in these images, however, will necessarily be diminished. This inverse relationship also applies to aerial imagery. For example, the highest-resolution civilian satellite imagery currently available has a ground sample distance of thirty centimeters per pixel. While this is sufficient to distinguish buildings, vehicles and large gatherings of people, it is unable to identify individuals. If more detail than this is needed, imagery acquired by aircraft or unmanned aerial vehicles (UAVs) can overcome this limitation, although the field of view will be much narrower.

In addition to geographic variations in image acquisition, environmental factors can also limit the availability and/or usefulness of remotely sensed imagery. In much of the world, for example, seasonal variations in cloud cover can obscure the surface from optical satellite imagery for months at a time. Technologies such as synthetic aperture radar (SAR) are capable of penetrating cloud cover. However, the data from such sensors is more costly than optical imagery, and analysis of it is often more challenging. In addition to clouds, other environmental factors that can complicate the use of remotely sensed data include smoke from fires, deep shadows such as those cast by buildings in crowded urban areas, and physical obstacles such as jungle canopy.

Government restrictions

Until recently, United States commercial regulations required all civilian satellite imagery sold in the United States to be down-sampled to 50 centimeters per pixel, even though the data were acquired at a ground sample distance of 30 centimeters.9 Politically sensitive

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areas of the world have also been targeted by governmental restrictions. For example, the Kyl-Bingaman Amendment to the U.S. 1997 Defense Authorization Act required that commercial operators restrict the collection of imagery of Israeli territory to lower resolution.10 Even in cases where no legislative restrictions are present, governments can still influence the availability of imagery by acquiring exclusive rights to certain images, ensuring that they cannot be re-sold to other customers.

**Ethical considerations**

In many circumstances, geospatial data may be able to reveal the identity of individuals without their knowledge or consent. For example, in the United Kingdom, researchers recently used a database of the locations of street art to reveal the probable identity of their anonymous creator.11 Similarly, many posts to social media contain geographic coordinates as part of their metadata. Although such information is often referred to as “volunteered geographic information,” in many cases the users are unaware that they are sharing their location.12 In these circumstances, ethical concerns, including privacy and informed consent, require careful scrutiny.13

**Cost**

For most organizations, particularly those with limited financial resources, cost is also an important constraint on the availability of data. Satellite imagery is generally priced per square kilometer, with different minimum order sizes for archival imagery as compared to targeted new collections. Companies also often charge higher amounts for data that include additional spectral bands or that were acquired with more recent instruments. Certain vendors also maintain a list of countries that they consider to be “high-demand” areas, and increase pricing accordingly. The cost of expert analysis can also be a constraint. As more information is collected, more analysis time will be needed to interpret the data and draw conclusions. Finally, producing quality results often requires powerful computer hardware and software, both of which are frequently expensive. While in some cases using open-source tools can mitigate these costs, the learning curve to use these tools can be steep, and the availability of support varies widely. Leveraging cloud computing solutions, in which digital storage and processing resources are rented from internet data centers, is another potential way to mitigate the cost of performing image analysis. However, these require reliable, high-speed internet connections, which may limit their usefulness in certain contexts.

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12 PetaPixel. 2016. This Map Plots the Location of 140,000 Accidentally Geotagged Photos. Available at https://petapixel.com/2016/10/04/map-plots-location-140000-accidentally-geotagged-photos/
Procedures for image acquisition and analysis

As with any physical or electronic evidence submitted in court, establishing a clear and verifiable chain of custody is essential. The private-sector entities that collect satellite images are usually not directly involved in the research conducted using their data. Because of this, any use of these images as evidence must address issues associated with the multiple steps in the chain of custody between the imagery provider, the analyst, and the courtroom. DigitalGlobe is one of the largest vendors of remotely sensed imagery in the world, with customers including governments, corporations, and scientists worldwide, including several who perform analysis for human rights documentation. Although the exact details of many aspects of DigitalGlobe’s operations are proprietary, in the interest of expanding the use of remote sensing as human rights evidence, their representatives have provided information regarding their space and ground-segment operations for the purposes of this report.

As a major international vendor of satellite imagery, DigitalGlobe has significant business incentives to ensure the integrity of its data products throughout the supply chain from production to delivery. The company’s license to operate its satellites from the U.S. National Oceanic and Atmospheric Administration requires them to adhere to a strictly controlled data protection plan for both the transmission and storage of imagery. The company has implemented this requirement by applying modern, U.S. Government-approved encryption and authentication techniques to ensure data integrity. In addition to this, they apply control mechanisms to ensure that any attempts to modify imagery or change signatures could be detected, and follow standard information security practices such as firewalls around their factory systems and datacenters. These measures, combined with procedures such as conducting background checks on operators, give them another layer of data protection and control to support the data integrity requirements of their customers.14

Once the imagery leaves the vendor and reaches the analyst, similar care must be taken to safeguard the integrity of the data and any products derived therefrom. Especially in cases where satellite-based evidence may eventually be used in litigation, certain practices are recommended for data transmission, storage, analysis, and archiving.

a) After satellite images are purchased, they are delivered from the vendor via encrypted electronic channels such as the secure file transfer protocol (SFTP) and include metadata concerning both the purchase of the image (reseller company, order number) and the imagery itself (extensive files containing information such as image identification number, collection date and time, exact bounding coordinates).

b) A copy should immediately be made of all the original files with the original data held separately – and not modified – to maintain this baseline information. If questions

arise regarding the imagery, the satellite imagery provider can use this baseline to confirm the origin of the file and that the files have not been modified.

c) All processing and analysis should be conducted on a copy of the imagery with all major modifications to the imagery, such as pan-sharpening or georeferencing, noted in a data log for future reference. All software packages used and relevant processing parameters should be included in this log, in addition to the name of the analyst.

d) Any known or potential sources of error should be included in the imagery analysis report. There are many different types of error. With regard to the spatial fidelity of the imagery, for example, when two or more images are aligned during the georeferencing process some error will be introduced, as the images are being warped to align with one another. Due to the different angles at which high-resolution imagery are collected and changes in topography across scenes, this warping may be significant. An RMS Error (Root Mean Squared) will be produced during this process, and should be included in the data log, as it indicates the severity of error produced in the alignment process; the higher the error, the greater the uncertainty will be in the positioning of the georeferenced image.\textsuperscript{15}

e) For visual (manual) imagery interpretation, the ability to quantify error will depend on the availability of ground truth. In many cases relevant to human rights violations, this may not be possible to collect due to factors such as the security situation in the field. However, the increasingly ubiquitous nature of volunteered geographic information, such as geotagged photographs, represents an emerging opportunity for collecting such ground truth (subject to the limitations associated with volunteered geographic information described previously). Additionally, it is possible that ground-based information may become available in the course of the investigation. In such cases, the error reporting should be updated appropriately. Other error metrics are frequently used in conjunction with automated classification algorithms used primarily with low-resolution satellite imagery. An exhaustive treatment of the broad range of ways that error can be quantified is beyond the scope of this document. In the review of any imagery analysis, however, a reporting of known or suspected sources of error is essential.

f) Analysis should be peer-reviewed by at least one qualified individual, either internal or external. If subsequent changes are made to the findings, this should additionally be noted in the data log.

g) All persons involved in the processing, analysis, and review of analysis should be listed in the data log, and their role in the analysis should be described.

h) All satellite imagery (including original and processed imagery), data analysis files, data log, analyst credentials, and a report of findings should be packaged and submitted to the requesting body through secure channels such as SFTP.

\textsuperscript{15} ESRI Support GIS Dictionary: RMS Error. Available at \url{http://support.esri.com/sitecore/content/support/Home/other-resources/gis-dictionary/term/rms%20error}
i) Backups to all copies of the analysis should be archived in a secure facility separate from the primary storage location to safeguard against data loss.

By following these standards, which were developed over twelve years by the staff of the AAAS Geospatial Technologies Project, analysts should be well-equipped to address most legal concerns regarding the use of remotely-sensed data as evidence, several examples of which are described in the following sections. Although these procedures are likely to constitute an effective safeguard against deliberate third-party manipulation of the imagery, they cannot fully protect images from misinterpretation on the part of the analyst. When dealing with data products as complex as remotely sensed imagery, multiple explanations of the underlying data will often exist, and identifying which of these is correct is a challenge, even for the most experienced analysts. While peer review is often effective at reducing the rate of such misinterpretation, it cannot eliminate it entirely, as even experienced analysts make mistakes. Furthermore, it must be emphasized that to be effective, the procedures described above must be implemented in an “end-to-end” fashion. Employing rigorous procedures in the analysis phase of an investigation, for example, cannot compensate for deficiencies in the provenance of the underlying data or deliberate malfeasance on the part of the imagery provider. If the integrity of the imagery or its associated metadata are lacking, any analysis based upon it will be compromised as well, irrespective of methods. An example of this would be if analysts were to draw conclusions from imagery acquired by an entity, such as a government, that is implicated in an investigation or otherwise has a stake in its outcome. The same concerns would be present if properly sourced data were examined by analysts with their own conflicts of interest.
3. Geospatial Technologies and Human Rights Evidence

Courts that adjudicate international crimes, including the International Criminal Court (ICC), generally have broader discretion to admit evidence than do national courts. There are several reasons for this discretion. First, the crimes for which these courts have jurisdiction – war crimes, mass atrocities, crimes against humanity – are by their nature difficult to understand, both in their inhumanity and in their complexity. These crimes are extremely challenging to document, as they can involve multiple actors working within chains of command, putting systemic human rights violations into effect across broad territories and even across national borders, often over the course of months or years. In addition, consistent with human rights principles of justice and due process, defendants are presumed innocent until proven guilty and guilt must be proven beyond a reasonable doubt. In short, the prosecutor’s burden is to meet the highest threshold of proof with evidence that the defendant has committed horrible acts, often over time and in multiple locations, and often by leveraging a complex web of power and influence.

With this solemn task before them, and mindful of the importance of these cases to post-conflict victim rehabilitation, reconciliation processes and efforts to rebuild the rule of law, international courts have discretion to review and admit evidence. This approach allows judges to include evidence that would not be allowed in some national courts, such as hearsay evidence. At the same time, the defendants’ rights are essential to due process and the public perceptions of justice at the court, so the court must scrutinize the evidence to ensure that only relevant and credible evidence is considered in the final verdict. There are no juries in international criminal cases; a panel of judges serves as the fact-finder and is presumed to be better equipped to assess the probative value of evidence than a lay jury. For this reason, strict rules requiring exclusion of evidence that might unduly prejudice a jury are not required.

The ICC has the most developed rules of evidence among the international courts and tribunals, having been informed by the rules and practices of the International Criminal Tribunal for the Former Yugoslavia (ICTY), the International Criminal Tribunal for Rwanda (ICTR), and other ad hoc and hybrid courts. Therefore, the ICC’s rules are discussed in detail below to illustrate how the Court has admitted and considered evidence from geospatial technologies in its cases. Readers should not presume that all courts’ procedures or interpretations of their rules of evidence are the same as the ICC’s. That said, while other courts’ rules might differ, the ICC’s rules of procedure demonstrate an emerging internationalized harmonization of international criminal law approaches to evidence.16

Admission and evaluation of geospatial evidence at the International Criminal Court

From its earliest days, the ICC has considered and relied upon evidence generated by geospatial technologies and remote sensing. This chapter outlines the rules and procedures that guide the Court in admission and evaluation of evidence, as set out in the Rome Statute and Rules of Procedure and Evidence, and summarizes the ways in which these types of evidence have been used in specific cases.

Rules and procedures

The Rome Statute’s Article 64 sets forth the powers of the Trial Chamber, stating that the Chamber has the power to determine the admissibility and relevance of evidence before it. Article 69 gives the Court authority to request evidence in addition to evidence submitted by parties to the case. Together, the Court has interpreted these two articles as a preference for the civil law system’s relatively flexible rules for admission and evaluation of evidence.17

The Rome Statute of the International Criminal Court

Article 64 Functions and powers of the Trial Chamber
9. The Trial Chamber shall have, inter alia, the power on application of a party or on its own motion to: (a) Rule on the admissibility or relevance of the evidence; and (b) Take all necessary steps to maintain order in the course of a hearing.

Article 69 Evidence
3. The parties may submit evidence relevant to the case, in accordance with article 64. The Court shall have the authority to request the submission of all evidence that it considers necessary for the determination of the truth.

This approach is further supported by the Court’s Rules of Procedure and Evidence. Citing Articles 64 and 69, Rule 63 directs the Court’s Chambers “to assess freely all evidence submitted in order to determine its relevance or admissibility” rather than in accordance with the evidentiary rules of the nation where the alleged crimes occurred. The Rules provide for two exceptions to the Court’s discretion related to protection of victims: Article 69(7) of the Rome Statute and Rule 71 of the Rules.

While the Court’s discretion to consider evidence is broad and flexible, it can be challenged by the parties in a case. Rule 64 allows parties to challenge the admissibility or relevance of evidence when it is submitted to a Chamber, limiting admissible evidence to information

with “probative value,” which has been interpreted by the Court as “the reliability and weight to be attached to the evidence concerned.”

This is distinct from relevance, defined as having the potential to influence the Court’s determination on at least one fact. For both, the Court must assess all of the evidence submitted and discussed at trial in making its final determination regardless of the type of evidence presented.

**Rules of Procedure and Evidence of the International Criminal Court**

*Chapter 4 Provisions relating to various stages of the proceedings*

*Section I Evidence*

**Rule 63 General provisions relating to evidence**

2. A Chamber shall have the authority, in accordance with the discretion described in article 64, paragraph 9, to assess freely all evidence submitted in order to determine its relevance or admissibility in accordance with article 69.

5. The Chambers shall not apply national laws governing evidence, other than in accordance with article 21.

**Rule 64 Procedure relating to the relevance or admissibility of evidence**

1. An issue relating to relevance or admissibility must be raised at the time when the evidence is submitted to a Chamber. Exceptionally, when those issues were not known at the time when the evidence was submitted, it may be raised immediately after the issue has become known. The Chamber may request that the issue be raised in writing. The written motion shall be communicated by the Court to all those who participate in the proceedings, unless otherwise decided by the Court.

**Rule 69 Agreements as to evidence**

The Prosecutor and the defense may agree that an alleged fact, which is contained in the charges, the contents of a document, the expected testimony of a witness or other evidence is not contested and, accordingly, a Chamber may consider such alleged fact as being proven, unless the Chamber is of the opinion that a more complete presentation of the alleged facts is required in the interests of justice, in particular the interests of the victims.

**Determination of probative value**

To determine the probative value of evidence before it, the Court must evaluate both authenticity and reliability. These are two distinct, but related, aspects of evidence. Evidence that is authentic has not been manipulated or tampered with. Reliability, by comparison, goes to whether the evidence is, in fact, documenting what the party submitting the evidence claims it to be. The Court must determine that both indicators are

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19 See note 24, ¶15.

20 See note 24, ¶15.


present; however separate rulings on each indicator are not necessary.\textsuperscript{23} The ICC e-Court Protocol was designed to maintain the authenticity and reliability of digital evidence after it has been submitted to the Court and to allow parties to independently assess its probative value.\textsuperscript{24}

**Authenticity: Has the evidence been tampered with?**

The Court has used several different methods to test the veracity of submitted evidence, depending on the type of evidence. When reviewing photographic or digital geospatial evidence, the Court has looked for both external and internal indicators of authenticity. External evidence of authenticity could include, for example, independent news reports that corroborate the facts alleged by the digital or photographic evidence, expert testimony, or witness testimony.\textsuperscript{25} The Court also has examined the chain of custody for assurances that evidence has not been tampered with. The Court prefers these types of external indicators over internal indicators such as time stamps or metadata as these are seen as having a greater potential for manipulation.\textsuperscript{26}

**Reliability: Does the evidence document the alleged facts?**

Evidence may be authentic, yet still unreliable. An often-cited example to illustrate the difference between these two concepts is a video that documented alleged war crimes in Sri Lanka. The government did not dispute the video’s authenticity, but claimed that the incident depicted in the video was staged.\textsuperscript{27} This is quite different from questioning whether the video had been altered from the original version.

To verify reliability, the Court prefers external corroborating evidence, especially witness testimony regarding the reliability of digital evidence. Being able to demonstrate the chain of custody is also important for reliability as that goes to the circumstances regarding the original source or creation of the evidence.

\textsuperscript{23} Bemba, Oct. 8, 2012. Decision on the Prosecution’s Application for Admission of Materials into Evidence Pursuant to Article 64(9) of the Rome Statute.\textsuperscript{19}


\textsuperscript{25} “The ICC generally favors viva voce evidence, or oral testimony.” See note 24, citing Lubanga trial chamber I, 26-27 (June 13, 2008). This preference is seen in the assessment of digital and photographic evidence, where the court has emphasized oral testimony as corroborating evidence of authenticity and reliability. See also note 28.

\textsuperscript{26} See note 31, p. 7.

Geospatial evidence at the International Criminal Court

Based on the principles, rules, standards, and practices described above, this section provides an overview of the Office of the Prosecutor’s use of remotely sensed evidence and then considers each case in which remotely sensed evidence has been submitted.

Use of remotely sensed evidence by the Office of the Prosecutor to investigate crimes

From the earliest investigations, the ICC Office of the Prosecutor (OTP) has looked to geospatial information as evidence for its investigations and cases. As a geospatial technologist in the OTP’s forensic science office has written, the OTP has “embraced” the use of geospatial technologies “in various forms that range from hard evidence to corroborative material, as well as an aid in investigations.”28 By 2012, “EO [earth observation] technologies and, in particular, satellite imagery, has played, and will continue to play, an important role in the opportunities available to the OTP in its quest to search for objective sources of evidence to prove the cases brought before the court.”29 As detailed in the case descriptions below, this prediction has proven correct.

The Court has an agreement with the United Nations Operational Satellite Application Programme (UNOSAT) to provide expert analysis of information derived from geospatial technologies.30 This formalized, ongoing relationship reflects the Court’s acknowledgment that geospatial analysis can provide important insights in the types of cases before it, as well as the need for specialized expertise to fully understand the probative value of this evidence.31

Consideration of remotely sensed evidence by the International Criminal Court

The section that follows reviews all the cases in which the OTP has presented geospatial evidence to date. The descriptions in each case explain the purpose for which the evidence was presented, at which stages the evidence was offered, the role of expert witnesses in presenting and explaining the geospatial data, and the Court’s findings related to the evidence.

29 See note 36, p. 239.
**Prosecutor v. Thomas Lubanga Dyilo** ICC-01/04-01/06 (Democratic Republic of Congo). When his arrest warrant was issued in 2006, Thomas Lubanga Dyilo was the former President and commander-in-chief of the Union of Congolese Patriots ( UPC). He was charged with conscripting hundreds of children who fought as soldiers during the conflict in Ituri province. As the first trial of and then the first conviction by the ICC, the Lubanga case set precedents for pre-trial and trial procedure including submission of evidence. Among these was the OTP’s successful use of satellite imagery and aerial photography to create geospatial “info-graphics.” These visual aids were provided as evidence that specific conflicts occurred on the dates alleged and to show the movements of child soldiers in relation to their training camps and the hostilities in which they engaged. The Prosecutor tied these visual aids to visits by Lubanga as evidence that he had knowledge of the children’s presence and command responsibility for their conscription, training, and involvement in conflicts. In 2012, Lubanga was found guilty and sentenced to 14 years in prison.

**Prosecutor v. Germain Katanga and Matieu Ngudjolo Chui** ICC-01/04-01/07 (Democratic Republic of Congo). At the time the Court issued the warrant for his arrest in 2007, Germain Katanga was commander of the Force de Resistance Patriotique in Ituri (FRPI). In 2014, the Court found Katanga guilty as an accessory to war crimes committed during a 2003 attack on the village of Bogoro. He was sentenced to 12 years’ imprisonment. The joint defendant in the case regarding the attack on Bogoro and crimes that followed, Matieu Ngudjolo Chui, was acquitted in 2012. The Appeals Chamber upheld the acquittal and Chui was released.

During the trial, the Court examined satellite imagery of the village of Bogoro submitted by the Prosecutor. The Prosecutor also submitted a “360 degree” visual presentation prepared using satellite imagery and aerial photographs taken by a drone. The evidence was submitted to explain the configuration of Bogoro and the specific locations where alleged crimes took place. An expert witness, Zoran Lessic, testified that he used satellite images and drone photography provided to him by the United Nations along with photographs he took himself to develop the panoramic presentation of Bogoro. He explained the technological process by which this presentation was created. Another witness testified that the original images and the resulting panoramic presentation

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32 Lubanga. Available at [https://www.icc-cpi.int/drc/lubanga](https://www.icc-cpi.int/drc/lubanga)
accurately depicted the village and its environment.\textsuperscript{39} The judgment does not specifically note the visual presentations or the testimony of the expert.

**Prosecutor v. Bosco Ntaganda** ICC-01/04-02/06 (Democratic Republic of Congo). In another case involving the violence in Ituri province, in 2014 the Court confirmed charges of war crimes and crimes against humanity, including murder, rape, sexual slavery, and conscription of child soldiers, against Bosco Ntaganda.\textsuperscript{40} At the time the Court issued the warrant for his arrest, Ntaganda was the commander of operations of the Patriotic Forces for the Liberation of Congo (FPLC). The trial began in September 2015.

During the confirmation of charges hearing, the Prosecutor presented a satellite analysis report documenting the burning and destruction of buildings by examining images of the same locations in 2002 and 2003.\textsuperscript{41} The Prosecutor used this satellite imagery during its opening statements in the trial.\textsuperscript{42} In December 2016, Lars Bromley, a geospatial analyst with UNOSAT, provided his interpretation of the satellite images as a witness for the Prosecutor.\textsuperscript{43} Mr. Bromley testified that the images that could be acquired in the present day indicated fires in the locations where alleged war crimes took place; however, only a limited number of images from 2002 and 2003 of the locations being investigated were available for analysis because images were not taken then at the same frequencies one would expect today.\textsuperscript{44} He went on to explain that the pattern of burning he observed indicated arson because areas between structures were also burnt. On cross-examination by the defense, Mr. Bromley conceded that he could not be certain about the cause of the fires as that is not something that can be assessed conclusively from the satellite images available to him, but that his conclusion was based on analysis of the overall settlement structures and comparisons of chronological images. The Court declared the presentation of evidence closed in March 2018.\textsuperscript{45} Until the closing briefs are complete and the judgment is announced, the extent of the Court’s reliance on the geospatial evidence and Mr. Bromley’s testimony will not be known.

\textsuperscript{39} See note 46, pp. 24-50.
\textsuperscript{40} Prosecutor v. Bosco Ntaganda. June 9, 2014. Decision Pursuant to Article 61(7)(a) and (b) of the Rome Statute on the Charges of the Prosecutor Against Bosco Ntaganda. ICC-01/04-02/06-309. Available at https://www.icc-cpi.int/CourtRecords/CR2014_04750.PDF
\textsuperscript{42} Ntaganda. Sept. 2, 2015. The Prosecutor Fatou Bensouda, Opening Statements. Available at https://www.youtube.com/watch?v=DKfkrXsr60
\textsuperscript{43} Ntaganda. Apr. 16, 2015. ICC-01/04-02/06-560 16-04-2015 1/10 NM T. Prosecution’s list of expert witnesses and request pursuant to regulation 35 to vary the time limit for disclosure of the report of one expert witness. p. 6. Available at https://www.icc-cpi.int/CourtRecords/CR2015_03995.PDF
\textsuperscript{45} Ntaganda. Mar. 16, 2018. Decision closing the presentation of evidence and providing further directions ICC-01/04-02/06-2259. Available at https://www.icc-cpi.int/CourtRecords/CR2018_01713.PDF
Prosecutor v. Bahr Idriss Abu Garda ICC-02/05-02/09 (Darfur, Sudan). The defendant, Mr. Abu Garda, is charged with war crimes related to an alleged attack in Darfur, Sudan in 2007. At the confirmation of charges hearing in 2009, the prosecutor presented satellite images taken before and after an alleged attack on a village in Darfur. However, the Chamber did not find sufficient evidence to support the Prosecution’s allegations that Abu Garda participated in planning the attack and refused to confirm the charges. The Chamber allowed for submission of this and other evidence at a later date; without additional evidence, the case is considered closed.

Prosecutor v. Abdallah Banda Abakaer Nourain and Saleh Mohammed Jerbo Jamus ICC-02/05-03/09 (Darfur, Sudan). The defendants were accused jointly of war crimes in an attack on the African Union Peacekeeping Mission in Darfur. The charges against Jerbo were terminated in 2013 due to evidence of his death. Pre-Trial Chamber I confirmed the charges against Banda in 2011. Banda remains at large so the trial has not yet taken place (the ICC does not try individuals in absentia).

In its application to the Court for an arrest warrant in the case (granted in 2014), the Prosecutor cited satellite images showing the condition of the military site where the peacekeepers were based before and after the attack. These images were purported to corroborate the dates of the attacks and the extent of the destruction.

Prosecutor v. Francis Kirimi Muthaura and Uhuru Muigai Kenyatta ICC-01/09-02/11 (Kenya). In January 2012, the ICC confirmed charges against Francis Kirimi Muthaura and Uhuru Muigai Kenyatta for alleged crimes against humanity committed during the violence that erupted in Kenya after the 2007-2008 elections in that country. As the case was moving to trial, the Prosecution appointed Mr. Lars Bromley (the same expert witness who testified in the Ntaganda case described above) as its expert witness for satellite image analysis. The Prosecution provided Mr. Bromley with detailed instructions to prepare a report on specific coordinates in Nairobi and Nakuru. However, the Prosecutor withdrew the charges against Muthaura in March 2013, and then withdrew the charges against Kenyatta in December 2014 due to insufficient evidence.

46 See note 36, p. 237.
Prosecutor v. William Samoei Ruto and Joshua Arap Sang ICC-01/09-02/11 (Kenya). Unlike the cases against Muthaura and Kenyatta, the case against William Samoei Ruto and Joshua Arap Sang for crimes against humanity during the post-election violence in Kenya went to trial in September 2013. The Prosecutor submitted satellite images, along with a report by Mr. Bromley of UNOSAT, as evidence of arson and other destruction.\textsuperscript{54} At trial, Mr. Bromley explained his analysis of the satellite imagery of the requested coordinates and dates (before and after the alleged crimes). He described in detail the method used to analyze the satellite data, through which he concluded that following the elections a large number of buildings had been deliberately destroyed by fire and others had “probably” been burnt.\textsuperscript{55} The Prosecutor then connected the timing of the destruction identified by Mr. Bromley to other evidence documenting the timing of the defendants’ movements between meetings and appearing on a radio show. Defense attorneys challenged the witness’s methods and whether one could determine whether fires were set deliberately through such images.\textsuperscript{56}

On 5 April 2016, Trial Chamber V(A) vacated the charges against Ruto and Sang, having concluded that the Prosecution had not presented sufficient evidence to prove the alleged crimes.\textsuperscript{57} According to an official press release from the ICC, “at the close of the Prosecution’s case, the evidentiary record contained 92 photographs, 27 maps, 77 items of audio/visual material, and over 8,000 pages worth of documentary evidence.”\textsuperscript{58}

Situation in Georgia. In January 2016, the Court authorized the OTP to open an investigation into crimes committed during the armed conflict between Georgian, South Ossetian, and Russian forces in 2008.\textsuperscript{59} The Prosecutor’s request to the Pre-Trial Chamber for authorization was based in part on analysis of satellite imagery.\textsuperscript{60} The investigation in this case is pending; no individual charges have been made at the time of this writing.

Prosecutor v. Ahmad Al Faqi Al Mahdi ICC-01/12-01/15 (Republic of Mali). The defendant, Ahmad Al Faqi Al Mahdi, was charged with war crimes related to intentional destruction of historic and religious structures in Mali in 2012. Mr. Al Mahdi appeared before the Court several days after the warrant for his arrest was issued in September 2015 and pleaded

\textsuperscript{58} International Criminal Court. Apr. 5, 2016. Ruto and Sang case: ICC Trial Chamber V(A) terminates the case without prejudice to re-prosecution in future. Available at https://www.icc-cpi.int/Pages/item.aspx?name=pr1205
guilty in 2016.\textsuperscript{61} Central to the case is the intentional destruction and damage to mausoleums and mosques in Timbuktu in 2012. Referred to in the case as the “Buildings/Structures,” the mausoleums and mosques in question are designated by UNESCO as World Heritage Sites.\textsuperscript{62} As evidence of this destruction, the Prosecutor submitted “satellite imagery of Buildings/Structures before and after their (partial) destruction.”\textsuperscript{63} The prosecutor presented these images during the trial that took place in August 2016, along with video footage recorded during and after the destructions took place, witness statements, official documents and statements by governments and international organizations, and media reports.\textsuperscript{64} Because this trial only concerned the matters of sentencing and reparations, not the defendant’s guilt, the prosecutor did not need to present evidence beyond a reasonable doubt. It therefore remains to be seen if this type of digital evidence, aggregated and arranged using satellite images as the foundation for geolocation, will meet that standard and what type of expert testimony will be needed to prove its probative value.\textsuperscript{65}

**Geospatial evidence in conflict-specific international criminal courts**

Beyond the ICC, international criminal courts established to try cases arising from specific conflicts have also admitted remotely sensed imagery as evidence. The first of these to examine satellite imagery was the International Criminal Tribunal for the former Yugoslavia (ICTY), established in 1993 and closed in 2017. Other courts with criminal jurisdiction that have considered satellite imagery evidence include the Special Court for Sierra Leone (SCSL) (2002-2013) and the Extraordinary Chambers in the Courts of Cambodia (ECCC) (2006-present). As described below, the ICTY admitted aerial images of the conflict captured by airplanes and satellites during the 1990s in the same manner as it did other photographs, rather than as scientific or highly technical evidence. This has also been the case in the ECCC, which has jurisdiction over crimes committed in the 1970s, when satellite technology was still very new and only managed by governments. In at least one case at the SCSL, however, the admissibility of satellite imagery was questioned.

**ICTY cases**

**Prosecutor v. Zoran Kupreskić et al. (ICTY IT 95-16-T).** The six defendants were indicted in 1995 (amended in 1998) for crimes against humanity and war crimes related to the 1993 massacre in the village of Ahmici. Aerial imagery was used to point out locations relevant to witness testimony, but the judgment issued in 2000 did not specify the source of this aerial


\textsuperscript{62}Ali Mahdi. Public Redacted Decision on the Confirmation of Charges against Ahmad Al Faqi Al Mahdi, ¶35-36. Available at https://www.icc-cpi.int/CourtRecords/C82016_02424.PDF

\textsuperscript{63}See note 70, ¶33.

\textsuperscript{64}See note 70, ¶33.

\textsuperscript{65}See note 11, pp. 318-319.
imagery.\textsuperscript{66} The Tribunal acquitted one of the defendants and convicted the other five, sentencing them to prison terms ranging from six to 25 years.

**Prosecutor v. Radislav Krstić** (ICTY IT 98-33-T). In Krstić, the defendant was indicted for genocide, crimes against humanity and violations of the laws of war in relation to ethnic cleansing campaigns carried out after the Serbian forces attacked Srebrenica in 1995. The 2001 judgment cited U.S. satellite images (referred to in the judgment as aerial photographs) as evidence of the defendant’s attempts to cover up the atrocities with mass burials and reburials.\textsuperscript{67} The judges also noted that the images provided a timeline for the crimes that corroborated other evidence. The Trial Chamber found the defendant guilty and sentenced him to 46 years in prison.

**Prosecutor v. Vidoje Blagojević and Dragan Jokić** (ICTY IT-02-60-T). As in Krstić, the defendants in this case were charged with crimes against humanity committed during the ethnic cleansing campaigns in Srebrenica.\textsuperscript{68} The Prosecutor used aerial images, provided by the U.S. Government, as evidence of mass graves.\textsuperscript{69} These images were entered through the testimony of forensic scientists, who also submitted photographs and other forensic evidence that resulted from exhumations of the graves. The Tribunal acquitted Blagojević of some of the charges, but found him guilty of aiding and abetting crimes against humanity. He was sentenced to 18 years in prison. Jokić was sentenced to nine years for aiding and abetting crimes against humanity, and was acquitted of the charge of murder.

**Prosecutor v. Dragomir Milošević** (ICTY IT 98-29/1). The defendant was charged with crimes against humanity and war crimes during the attacks on Sarajevo in 1994 and 1995. During the trial, the Prosecutor used a satellite image to establish the relative locations of landmarks described in witness testimony and to challenge a defense witness’s description of how specific military actions unfolded.\textsuperscript{70} The tactic was successful; the judges found the witness’ overall testimony unconvincing, as his conclusions did not take into account the full range of possibilities shown on the image and identified by other witnesses. In 2007, the Tribunal convicted the defendant on five charges and dismissed two counts related to unlawful attacks on civilians. He was sentenced to 33 years’ imprisonment.

**Prosecutor v. Vujadin Popović et al.** (ICTY IT-05-88). In Popović, seven men were tried for war crimes and crimes against humanity committed during the Srebrenica massacre. Court


\textsuperscript{69}See note 76 at pp. 255, 265, 312, 313.

documents refer to “aerial images” – images from both satellites and aircraft – that the United States provided to the United Nations Security Council as evidence of mass killings in Bosnia. However, testimony in Popović reveals that U.S. officials did not release details about the sources of these images, presumably for national security reasons. The images were used during the testimony of two witnesses: Jean-Rene Ruez, the chief investigator for the ICTY on Srebrenica, and Richard Butler, an expert in criminal investigations and military intelligence. The first testified that he had removed a date and a white box from the images, while the second testified that the images could not be altered.71

During the trial, one of the defense attorneys, Ostojić, argued that the discrepancies between Ruez’s and Butler’s testimonies suggest that the images had been manipulated: “I think that they [the Prosecutor’s team] have not established the proper foundation or authenticity for the documents to be admitted into evidence.” The Prosecutor countered that the events the images show are corroborated by witness testimony and official documents and that the only changes made to the image was a date blotted out and some changes to a white box. The Trial Chamber responded:

“Our decision is that the reasons adduced by you, Mr. Ostojić, particularly yesterday, for not admitting these documents go to weight rather than the criteria necessary for admission. The Trial Chamber is satisfied that sufficient evidence on the relevance and the probative value of these aerial images has been adduced by the Prosecution. Therefore, all aerial images introduced are admitted without prejudice, of course, to the weight that should or should not be given to them at the end of this case.”

These images are referenced in the judgment (2010) under the heading ‘Aerial Images’:

“72. In order to establish the alleged burial and reburial operation, the Prosecution submitted aerial images showing disturbances in the earth after the alleged murders were committed that were provided to it by the United States Government. 73. Beara argues that the aerial images tendered by the Prosecution are not reliable. Richard Butler testified that he did not believe the aerial images could be altered by anyone whereas Jean-René Ruez, the Prosecution witness through whom the aerial images were tendered, explained why he had added and removed dates on certain aerial images. Only Beara raised an objection to the admissibility or reliability of the aerial images. On 7 February 2008, the Trial Chamber held that sufficient evidence had been adduced regarding the relevance and the probative value of all aerial images tendered by the Prosecution, and admitted them into evidence without prejudice to the weight that would be attached to them at the end of this case.

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74. In his Final Brief, Popović argues that the disturbance of the earth, shown on certain aerials, cannot be properly linked to the alleged crimes due to lack of comparative aerial imagery. He further argues that ‘for some images we do not have any link which connects it with the particular place where the grave is located, and this is because none of the images have site code or coordinates.’ 75. The Trial Chamber does not find that the weight of the aerial images is adversely affected by Ruez’s explanation that for the purposes of this case, he had erased certain dates, marked by the United States Government in white, and replaced them by dates marked with a colour pen. The Trial Chamber is of the view that Popović’s argument that insufficient images were tendered to rely on the description of those images given by the United States Government is without merit. Lastly, particularly in light of the extensive evidence given by Ruez, Dean Manning, and Richard Butler, the Trial Chamber has found the aerial images to be authentic and reliable, and has accorded them due weight.”

The Trial Chamber looked to external indicators of the images’ authenticity and reliability, including expert witness testimony but also consistent testimony from eye witnesses, to assess whether the images were admissible. The judges determined that other questions about the images went to how much weight the court should give the images in the context of other evidence. The fact that the images were supplied by the U.S. Government appears to have bearing on the Trial Chamber’s conclusion.

**Prosecutor v. Zdravko Tolimir** (ICTY IT 05-88/2-T). The defendant was charged with crimes against humanity, including genocide, extermination, murder, forcible transfer, and deportation for his activities in Srebrenica and Žepa between 1992 and 1995. According to the 2012 judgment in this case, the Prosecutor submitted aerial images provided by the U.S. Government as evidence of “particular locations of gravesites and reburial activities, buildings and vehicles, large groups of prisoners, and bodies.” The defendant questioned the reliability of this evidence since no information was made available about how the images were delivered or whether they had been modified. The court acknowledged the lack of information about the origin of the images, but went on to state:

“70. However, this does not impair the credibility of aerial images in general. Dean Manning and Jean-René Ruez—both former OTP investigators—have extensively testified about their use. Aerial images have often complemented forensic archaeological or anthropological reports. The fact that Manning, Ruez, and Richard Wright, an archaeologist, first identified and then indeed located gravesites by aerial images points to their authenticity and utility as evidence. In addition, the interpretation or authenticity of an aerial image has often been corroborated by

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72 See note 79.
74 See note 81, ¶67.
witnesses’ testimony. The Chamber thus finds aerial images generally to be reliable and of probative value.

As in Popovic, the judges looked to external indicators from witnesses. In this case, it is interesting that the aerial images were corroborated by a scientific expert witness, an archaeologist whose expertise in that related field of research corresponded to what could be seen in the images. However, this is still an example of admitting images through a witness as documents, not as the result of scientific analysis. The Trial Chamber found the defendant guilty of six of the eight charges and sentenced him to life imprisonment.

**Prosecutor v. Radovan Karadžić** (ICTY IT 95-5/18-T). The defendants were indicted for crimes against humanity including murder, persecution, and extermination, as well as genocide and violations of the laws of war such as attacks on civilians and taking hostages, all committed between 1991 and 1995. During the trial, the Prosecutor presented aerial photographs and satellite images to show the relation of different buildings to each other, including a stadium that was used as a detention center. This evidence was submitted to corroborate witness statements describing how detentions, torture and executions were carried out in those locations.

The defendant also used satellite images to make his case. Mile Poparić, an expert in military weapons and equipment, testified for the defendant. His analysis, which was based in part on satellite images, concluded that some of the witness testimony presented by the Prosecutor could not have occurred in the way it was presented to the court. While the Trial Chamber found some of this locational testimony persuasive, it did not find other parts of Poparić’s testimony credible. For example, his conclusions regarding the physical injuries suffered by victims were rejected because he did not have medical expertise. Another witness, Dragomir Milošević (convicted of related crimes in 2007), used satellite images to explain his testimony about troop movements. However, the court found his statements were not credible in the context of the overall body of evidence presented by the Prosecutor. In 2016, the Tribunal found Karadžić guilty of 10 of the 11 crimes charged and sentenced him to 40 years in prison.

**Prosecutor v. Ramush Haradinaj, Idriz Balaj, and Laji Brahimaj** (ICTY IT-04-84-I). The three defendants were initially indicted in 2005 for being members of a joint criminal enterprise that kidnapped, tortured, and killed civilians. In 2008, the Trial Chamber acquitted two of the defendants and found one guilty. The Prosecutor appealed and was granted a partial retrial, which resulted in acquittals. The new trial started in 2011 and the final judgment was announced in 2012. The 2008 judgment references aerial imagery of

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77 See note 83, ¶3854-3896.

Kosovo used by several witnesses to point out locations relevant to their statements, but the judgment did not specify the source of this aerial imagery.

**ECCC cases**

**Prosecutor v. Kaing Guek Eav alias Duch** (001/18-07-2007-ECCC/SC). This conviction in 2010 was the first by the ECCC. The defendant was the chairman of a detention center at which over 12,000 people were executed. An aerial image of the detention center, included as an Annex to the judgment, was used to assist witness testimony.⁷⁹ The Prosecutor also submitted reports from the Cambodian Genocide Project at Yale University that drew upon Landsat images into evidence.⁸⁰

**Prosecutor v. Nuon Chea and Khieu Samphan** (Case 002/01). The defendants were indicted for crimes against humanity related to the forced movement of civilians and executions. Aerial imagery of Phnom Penh was used to corroborate witness testimony about the forced migration of people in the area in 1975.⁸¹ Images of detention centers were also submitted. In its 2014 judgment, the Tribunal found the defendants guilty of some of the charges and acquitted them of others. Both defendants were sentenced to life imprisonment.⁸²

**SCSL – Prosecutor v. Charles Ghankay Taylor** (Case No. SCSL 03-02-A)

In both the ICTY and the ECCC, the satellite images were not scrutinized as digital evidence. Thus, probing the authenticity and reliability of these images did not involve the type of examination of expert witnesses the ICC has carried out in its cases. This shift from “aerial images” to questions raised by digital satellite images, especially those acquired by private corporations, was evident in the SCSL during the prosecution of Charles Taylor, former President of Liberia.⁸³

Taylor was indicted in 2003 for organizing and ordering crimes against humanity during the civil war in Sierra Leone. During the trial, the Prosecutor presented Google Earth imagery to illustrate witness testimony by asking the witness to point out geographic features on the image. This imagery was not provided by a government source, was not based on an

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⁸² See note 90.

expert’s report, nor did the Prosecutor offer an expert witness to interpret or verify the imagery.

The first time the Prosecution tried to introduce a Google Earth image during witness testimony, the Court ruled that the satellite image was inadmissible because the witness was unable to identify the terrain in the photograph. The Court had similar foundational concerns when the Prosecution tried to use satellite images during a cross-examination of another witness:

“There is no legend on these Google maps that you [the Prosecution] keep giving us, unlike ordinary topographical maps that have legends to explain what is what.” ⑧₄

The same problem occurred when the Prosecution sought to introduce a satellite image to identify a bridge leading into Freetown:

“Why I might be hesitant to take these videos, these Google satellite videos, is because there usually isn’t a legend and you are saying no this is the bridge and we are all looking at it, but the witness isn’t even marking anything on the map. And six months from now, we don’t know what we will be looking at. That’s why we are hesitant to take these exhibits in. And we would prefer a fixed map where someone can say, yes, this is Orugu Bridge and even mark it.” ⑧₅

The Defense reinforced the Court’s concerns, arguing that the evidence was unreliable:

“[T]here are maps that are downloaded from Google. We don’t know if the latitude and longitude reflected at the bottom of the document matches [the location in question]. We don’t know if this is a photo, for example, of Southern California... And they want to show this image from Google to a witness, asking the witness to confirm or deny that such and such is where a particular building was located. Let’s bear in mind the witness before the Court and let’s bear in mind ordinary folks’ ability to understand satellite imagery. The witness before the Court is not an expert. I certainly don’t have an understanding of latitudes and longitudes to know exactly what this corresponds to. And so this information, as I am proposing to your Honours, is unreliable... These Google Earth photographs have a copyright of 2010... We’ve no idea what the terrain was like during the course of the civil war.” ⑧₆

The Court held that the Prosecution had not established the witness’ competence to give evidence about the document, and thus the document could not be admitted through the

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⑧₅ See note 92.
testimony. While this did not have an impact on the outcome of the trial – the defendant was convicted in 2012 and sentenced to 50 years in prison – these transcripts highlight the types of evidentiary questions that ought to be addressed by a witness who has conducted the geospatial analysis, as has been the practice in the ICC, when the images are accessed from private entities.

**Geospatial evidence in regional human rights courts**

Not all human rights courts have jurisdiction over criminal cases. Human rights courts, including the European Court of Human Rights and the Inter-American Court of Human Rights, serve as appellate bodies when national courts do not uphold the human rights commitments articulated in the respective international and regional treaties. Because these courts are not trying an individual defendant for crimes, they do not have the same due process or fair trial concerns as criminal courts that can sentence a defendant to imprisonment. As a result, the threshold for evidence is lower than “beyond a reasonable doubt.” In addition, these courts do not hear cases in the first instance, but are the end of an appeal for justice, building on litigation that has usually gone through at least one round of appeals in a national court system. The cases are brought by plaintiffs – individuals, communities, or organizations – against a national government, asking for relief from a violation of the applicable human rights treaty.87

With jurisdiction over a much broader range of human rights obligations and more flexible rules and procedures for evidence, the regional human rights courts have been open to evidence presented using geospatial technologies when it has been presented in cases. Similar to the cases described above, plaintiffs have presented the Inter-American Court of Human Rights with aerial imagery to document mass atrocities, such as in the case of *Santo Domingo Massacre v. Colombia* (2012). In that case, a number of maps, an aerial photograph, and a “Skymaster Video” are noted in the preliminary objections, merits, and reparations documents.88

Indigenous communities have used more sophisticated geospatial technologies to document their territories, environmental damage, and illegal encroachments. In *Sawhoyamaxa Indigenous Community v. Paraguay* (2006), expert witness Andrew Leake used satellite imagery to outline the territory, available resources, land use, and deforestation patterns of land the Sawhoyamaxa claimed as their indigenous territory. Both the satellite imagery and the testimony of Mr. Leake were noted (without additional information) in the judgment. The government of Paraguay protested that Mr. Leake’s report was not given before a public official whose acts command full faith and credit of the courts, but the Court based its admission of the evidence on the fact that it had admitted

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such statements before, provided that legal certainty and the procedural equality between the parties were not impaired. It is unclear why Mr. Leake’s expert opinion was not given before a proper official, but it was a sworn statement.89

Similarly, in Saramaka People v. Suriname (2007), expert witness Peter Poole helped the Saramaka People map their territory and the resources they used within it. In the judgment, the Court stated that this map, when considered alongside aerial imagery and anthropological testimony regarding cultural traditions connected to the land, adequately documented the Saramaka People’s claims to property rights, including “their right to manage, distribute, and effectively control such territory.”90 Other Inter-American Court of Human Rights cases that cite maps and aerial photographs include Maria Salvador Chiriboga v. Ecuador (2008)91 and Xakmok Kasek Indigenous Community v. Paraguay (2010).92

In the European Court of Human Rights, satellite imagery has been used to show internal displacement as a risk to immigrants in deportation proceedings. In Sufi and Elmi v. United Kingdom (2011), the U.K. sought to deport two Somali refugees to Somalia after they were convicted of criminal offenses in the U.K. Sufi and Elmi claimed that they would be in serious danger if forced to return to Somalia. Sufi and Elmi submitted reports by the United Nations Office of the High Commissioner for Refugees (UNHCR) regarding the current state of affairs in Somalia to illustrate the potential dangers that awaited them if they were deported. These reports used satellite imagery of Somalia to demonstrate the movement of people in that country and estimate the number of internally displaced people. In its judgment, the Court stated that:

“According to the UNCHR, there were around 370,000 displaced persons in Mogadishu and 360,000 in the Afgooye Corridor. However, it was possible that there were great margins of error as the UN estimates were based on satellite images and it was thought that many houses had been built to mislead aid organisations... The [UNCHR] report noted that there had been a rapid urbanization of the Afgooye corridor, which was clearly apparent in the satellite imagery. Structure in Afgooye were becoming more permanent as hopes faded for a safe return to the capital any time soon... Indeed, the fact-finding mission had indicated that the Afgooye Corridor was taking on a more permanent character, with an increasing number of businesses

“operating in the area. One interviewee had recorded that satellite pictures showed evidence of settling, urbanization and normal life.”

Very few documents from this trial are available online, limiting public understanding of how these reports and the geospatial analysis they contained were admitted into evidence. It appears that although the Court questioned the accuracy of the estimates of internally displaced persons, they accepted that satellite imagery can demonstrate the movement of people and development of areas. In another case, *Moghaddas v. Turkey* (2011), a satellite image of a border crossing between Iraq and Turkey was used to corroborate the testimony of the victim.

More recently, in the case of *Sargsyan v. Azerbaijan* (2015), the European Court of Human Rights relied on satellite imagery to determine whether the petitioner, as a person displaced by conflict, had been denied access to his property in violation of Article I of Protocol 1 to the European Convention on Human Rights and the Pinheiro Principles on Housing and Property Restitution for Refugees and Displaced Persons. To make this determination, the Court had to determine (1) whether Azerbaijan controlled the territory where the property was located and (2) if so, that it did so in such a way that prevented the petitioner, an ethnic-Armenian forced to flee when his village was attacked, from returning to his property after the conflict ended. The Court’s 2015 judgment on behalf of the applicant cited a AAAS report assessing high-resolution satellite imagery of Gulistan, Azerbaijan between 2002-2012. The Court itself requested this report from AAAS and relied on its findings to establish positions of the Azerbaijani military. The Court did not invite testimony from the analysts who wrote the report or from other expert witnesses, nor is there a specific finding in the judgment regarding the report’s probative value.

Such testimony and the opportunity for cross-examination may have resolved the concerns raised by Judge Pinto de Albuquerque in his dissenting opinion, which outlined “serious doubts about the use of this evidence.” The questions raised in the dissent could have been explored with an expert witness during hearings. Without that opportunity, the dissent observes, the Court drew its own conclusions that scientific limitations cited in the report – “insufficient imagery, cloud cover, spectral properties of the imagery, physical geography of the region, and general difficulties in conducting multi-year assessments” – did not undermine the accuracy and credibility of the findings.

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93 See note 94, Dissenting Opinion of Judge Pinto de Albuquerque, p. 116.
Summary

This overview of cases makes apparent the value of evidence derived from the use of geospatial technologies. Satellite imagery can provide important documentation of massacres, mass graves, and widespread arson. They can also provide chronologies of attacks, upon which to corroborate other evidence, especially witness testimony, even for crimes committed many years ago.

Beyond chronologies and images of what happened when, these cases also provide glimpses of the potential for improving human rights documentation when the power of geospatial technologies analysis is more fully applied. As shown in Saramaka People vs. Suriname and Sawhoyamaxa vs. Paraguay, using geospatial evidence to connect anthropological research and participatory mapping has led to landmark decisions in upholding indigenous land rights in the Americas. The advanced technologies that connected satellite images with other digital evidence in the Al-Mahdi case further show what might be possible as courts and attorneys become more comfortable with geospatial technologies.

Witness testimony is key to developing that comfort and ensuring that this evidence continues to meet the necessarily high evidentiary thresholds for international courts and tribunals. As seen in the cases above, expert testimony has been helpful for explaining the technologies, analysis methods, and limitations. However, as there have only been a small number of cases in which geospatial technologies have played a critical role, international courts have not established settled practices for expert witnesses in this field. The dissent in the Sargsyan case provides an important caution for the use of this type of evidence, even when it is requested by a court, which the ICC can do under Article 69 of its Rules of Procedure and Evidence. Thus, the next section examines principles applied by some national courts when considering admission of scientific experts regarding geospatial analysis.
4. The Future of Geospatial Evidence in International Courts: Principles for Predictability

As described in the previous section, some courts have viewed digital satellite images as the equivalent of analog aerial photographs, and in some cases, that is exactly how they are used by the party proffering the evidence: very detailed snapshots taken at known dates and times, at a location that can be externally verified. In these cases, courts do not always need an expert in geospatial technologies to assess the probative value of the evidence. This is particularly true when the provenance of the image is not in question and when it was being used to corroborate other evidence, such as witness testimony, rather than to establish a fact independent of other evidence. However, the failed attempt to use a satellite image printed from Google Earth in the SCSL’s trial of Charles Taylor is instructive. This case marked a turning point in the use of privately sourced geospatial evidence in international criminal prosecutions, as attorneys and judges realized that such images must be scrutinized to ascertain whether the images have been manipulated before publication. More recently, courts have recognized geospatial evidence as a type of scientific evidence that must be scrutinized in the same way as other scientific evidence: through testimony by the expert who prepared the report.100

The international criminal courts do not have special rules or procedures for scientific experts as distinguished from other witnesses. This contrasts with many national courts, including those of the United States, which have rules of evidence regarding scientific conclusions that assist courts in their role as factfinder. Scholars and practitioners have recommended that the ICC adopt the Daubert principles adopted by the U.S. Supreme Court for determining the probative value of scientific expert witness testimony, as have the courts of several other nations.101 The principles are generally consistent with the ICC’s rules of evidence and the ICC could find them useful as digital evidence becomes more prevalent. However, it is important to understand the Daubert principles in the context of the United States legal system, which relies on precedent and is oriented toward protecting specific constitutional rights that are not relevant in international criminal courts.

Admission of scientific evidence under Daubert

U.S. Federal Rules of Evidence 104(b) and 702 provide the standards for determining whether scientific evidence is admissible in U.S. Federal Courts.102 These Rules were interpreted by the U.S. Supreme Court in Daubert v. Merrell Dow Pharmaceuticals as an

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100 See note 39.
101 See note 36.
obligation judges must undertake, rather than at their discretion. Rule 702 makes explicit that trial judges must scrutinize scientific and technical evidence for relevance and reliability in order to prevent “junk science” from being presented to a jury. For scientific evidence, the pertinent question for determining reliability is, “Is this grounded in the methods and procedures of science?” Recognizing that empirical evaluation is what distinguishes science from other fields, the Court outlined several possible, but non-exclusive, ways trial judges can make this determination:

- Has the theory or technique been tested?
- Has it been subjected to peer review and publication?
- Does the research method presented have known or potential error rates?
- Are there standards in place to control the method’s or technology’s operation?
- Is there general acceptance of the methodology within the scientific community?

These principles apply to all scientific and technical fields, including “technical or other specialized knowledge,” based on “skill- or experience-based observation” and “soft” sciences such as economics and psychology that are more difficult to replicate than some other types of scientific research. While application of the Daubert principles is mandatory, the principles allow courts broad discretion in their assessments of the probative value of scientific and technical evidence.

Subsequent U.S. Supreme Court decisions provide additional guidance and interpretation of the Daubert principles that international courts might find useful. For example, in order to conform to the principles, an expert witness must explain both “how and why” a scientific report’s conclusion was reached. This explanation applies to both the underlying studies on which the expert witness’s research relies and the “intellectual rigor” of the witness’s own conclusion. Courts are not obligated to accept the expert’s opinion even if they accept the underlying data. In other words, a witness could base his or her opinion on sound research but then jump to baseless conclusions. Conversely, the expert could provide a logical rationale for his or her conclusions, but base that logic on underlying scientific studies that are not themselves credible. A court must scrutinize both for relevance and reliability.

As a framework for reviewing the admissibility of scientific expert testimony on which judges might not have specific experience or knowledge, the Daubert principles have much to offer international courts. They provide guidance for judges to assess whether a particular expert’s testimony is credible and thus can be relied upon for determining

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104 See note 106, p. 590.
105 See note 106, pp. 593-594.
109 See note 111, p. 152.
110 See note 111, p. 146.
authenticity and reliability. However, if the Daubert principles are to become standard practice in international criminal trials, they should be carefully adapted to be consistent with each court’s rules.

There are several reasons to transfer the principles carefully. The Daubert case and all of the cases in which the U.S. Supreme Court has interpreted Daubert were personal injury cases where the standard for evidence is “by a preponderance of the evidence,” not “beyond a reasonable doubt.” In fact, few U.S. courts hearing criminal cases have applied the Daubert principles to forensic science offered by prosecutors.\textsuperscript{111} In United States v. Nacchio, the appellate court rejected the argument advocating a higher standard for reviewing scientific evidence in criminal cases.\textsuperscript{112} This is in part because a different rule of evidence, Rule 403, allows exclusion of testimony if its prejudicial effect substantially outweighs its probative value.\textsuperscript{113} The broader discretion for admitting evidence in international criminal courts exists in part because there are no juries to be prejudiced. For this reason, and for other due process considerations, it is important to remember that the Daubert principles emerged from, and have been interpreted and understood within, an adversarial common law system. Thus, while the Daubert principles are a useful tool for judges who must determine the probative value of scientific evidence, some of the specific ways in which the principles are applied in U.S. courts should not be lifted verbatim into international criminal law.

This caveat does not lessen the main advantage of the Daubert principles, which is that they provide a predictable way for courts to assess scientific testimony without expecting judges to have detailed knowledge of every scientific field on which an expert might testify. Rather, application of the principles requires that courts understand the manner in which scientific research is generally conducted and the methods by which scientists draw their conclusions. For example, scientific conclusions tend not to be based on causal relationships in each individual underlying study but rather on a body of scientific research from multiple disciplines and methods:

“Science proceeds by cumulating and synthesizing evidence until there is enough for a new paradigm. That does not mean every study meets the most rigorous scientific standards. Judgment is required in determining which inferences are appropriate, but an approach that encourages looking at studies sequentially rather than holistically has costs that must be considered.”\textsuperscript{114}

\textsuperscript{111} See note 105, p. 27.
\textsuperscript{112} United States v. Nacchio (10th Cir.) 2009. 555 F.3d 1234.
\textsuperscript{113} See note 105, p. 29.
\textsuperscript{114} See note 105, p. 21.
Jurists and scholars have suggested several ways judges can better understand scientific and technical matters for their fact-finding responsibilities. For example:

- In his concurring opinion in *Joiner*, U.S. Supreme Court Justice Stephen G. Breyer recommended that judges consider appointing independent scientific experts, as allowed by U.S. Federal Rules of Evidence 706;\textsuperscript{115}
- U.S. District Court Judge William Alsup has ordered parties to jointly appoint a panel of experts to provide him a “tutorial” when the case before him involves highly technical scientific information;\textsuperscript{116}
- Judges can invite amicus briefs from relevant organizations to inform them on technical matters;\textsuperscript{117} and
- Courts can appoint “special masters” to hear evidence on their behalf and make recommendations to them when complex scientific evidence, such as environmental science, is critical to the outcome of a case.\textsuperscript{118}

In conclusion, as highly technical evidence – including evidence generated by geospatial technologies – becomes more widely available, the Daubert principles provide a sound framework for assessing whether this evidence is credible. The next section explains how the Daubert principles apply specifically to geospatial technologies, providing courts with a basis for assessing the credibility of experts in this field to conduct geospatial research and form sound conclusions that are relevant and reliable.

**Applying the Daubert principles to evaluate experts in geospatial technologies**

As explained in previous chapters, geospatial analysts apply widely used and recognized technologies and methods. U.S. courts applying Daubert have found geospatial data to have sound scientific foundations with reliable principles and methods for analysis with GIS. That said, each expert witness must be evaluated individually and the expert’s specific findings must be properly applied to the facts of the case before the court.\textsuperscript{119} This section outlines questions international courts can ask to evaluate an expert’s testimony regarding geospatial evidence, in compliance with both the ICC’s rules of evidence and the principles for assessing scientific evidence articulated in Daubert.

1. What are the expert’s qualifications? Courts must assess whether the expert is qualified to provide the proffered testimony. This involves two components:
   a. Proper credentials (“skill, experience, training or education” which for geospatial evidence would include advanced degrees in geography, planetary

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\textsuperscript{115} See note 110, pp. 153-154.
\textsuperscript{117} See note 105, p. 30.
science, archaeology, or other fields in which the expert has gained in-depth understanding of research methods and analysis of geospatial data).\textsuperscript{120} 

b. Experience in the field, including personal experience applying the research methods and knowledge of the field, its standards, and its codes of conduct.

These can both be addressed with submission of a curriculum vitae (CV) when offering the witness to the court, as has been done by the OTP.\textsuperscript{121}

2. What is the scientific knowledge and what are the methods on which the expert relied? The expert’s report should explain the specific technologies and methods that were applied to conduct the research and draw conclusions. Methods and techniques that have been tested, peer-reviewed, and published should be cited as such. If innovative methods are applied, the underlying research that forms the basis for these methods must be detailed, in greater depth than would be needed for a paper to be published or presented within the field. Known or potential error rates should be articulated, as should the standards used by the expert to prevent mistakes.

3. Did the expert apply these scientific methods to the facts of the present case? Even if the court agrees that geospatial technologies are based on sound scientific foundations, the expert must have applied those scientific methods to the facts of the case with “intellectual rigor.” More specifically, geospatial analysts who are well-qualified and using the most widely recognized methods and technologies might still jump to unfounded conclusions. It is the court’s responsibility to find those conclusions not reliable, even if the underlying science is sound.

4. Is the expert objective? The scientific expert’s testimony should not be biased toward or against the defendant. For example, the ICTY has rejected scientific testimony when the court found the scientist had made statements supporting NGO advocacy goals related to the case in which he was testifying.\textsuperscript{122} In U.S. courts, the determination of witness credibility is assigned to the jury, so it is not considered an element of a Daubert review. In the ICC and other international courts, however, judges must include credibility as part of their evaluation of scientific evidence.

In practice, the ICC and other criminal courts have asked these questions, or similar ones, to comply with their rules of evidence. If these questions are made explicit in rules of procedure, then they are predictable to both the prosecution and the defense. Predictability enables the prosecutor to determine which evidence to present, an important consideration with limited budgets that often cannot accommodate all of the latest research and technology. Predictability also allows the defense to effectively cross-examine the prosecution’s evidence and present its own, an essential element of a fair trial. As seen in

\textsuperscript{120} U.S. Federal Rules of Evidence, Article VII. Opinions and Expert Testimony, Rule 702: Testimony by Expert Witnesses. Available at https://www.law.cornell.edu/rules/fre/rule_702

\textsuperscript{121} Curriculum Vitae of Mr. Lars Bromley. Available at https://www.icc-cpi.int/RelatedRecords/CB2013_01423.PDF

the case review in the previous chapter, the admission of geospatial evidence has not always been predictable, or even admitted with an explanation by an expert. This will change as attorneys and judges become more comfortable with geospatial technologies as a reliable form of evidence when accompanied by explanations from a well-qualified expert witness.
5. Conclusions and Recommendations

Geospatial technologies have provided important evidence for holding perpetrators of mass atrocities accountable, upholding the rights of indigenous peoples, and documenting an increasingly broad range of human rights concerns. As human rights advocates and litigators deepen their understandings of the capabilities of different sensors and the analytic tools available through GIS, the role of geospatial technologies in human rights likely will continue to expand. The challenge for all actors involved in developing and using this growing body of evidence is to ensure the analysis is based on rigorous scientific methods so it can be used in courts. This has implications for jurists, analysts, NGOs, governments, and private suppliers of the image data.

**Jurists**

1. Consider adapting the *Daubert* principles, in a manner consistent with other rules and principles, as a rigorous way of assessing scientific evidence through the testimony of expert witnesses.

2. In cases that involve highly technical or specialized scientific research, consider appointing an independent scientific advisor or a "special master" who can provide an impartial and informed assessment of the research and analysis presented by the parties.

3. Recognize that the presence of error is not a failing, but an inevitable component of any scientific analysis. Consider whether error has been documented, quantified, or otherwise addressed in testimony. Robust analyses will be open about potential sources for error, explore varying interpretations of the data, and refrain from making definitive claims.

4. Understand that geospatial technologies encompass multiple technological tools, and that certain methods are well-tried and tested, and others may be highly experimental. When evaluating evidence, establish which are which.

5. Recognize that the requirement for scientific rigor does not imply that practices must be complicated; simple methods can still be rigorous.

**Geospatial technologies analysts, including those who might be called as expert witnesses**

6. Methods should be documented as described in this report. Where multiple techniques or approaches to a question are available, this documentation should
include information about why a particular method was chosen, so that the rationale is clear for others (e.g., attorneys or judges) who might question that choice later on.

7. The provenance of all data must be documented to the fullest extent possible. If sources of potentially questionable reliability are used (e.g., social media posts, etc.), that fact must be made fully known in the analysis report. The data may still prove useful, e.g., through corroboration via other types of data, but any such approaches to addressing reliability must be thoroughly documented.

8. Rigorous analysis does not preclude experimental methods. However, these should be identified as such, and should only be employed if established methods are insufficient to the task. Consider that such methods may not meet the necessary standards of evidence for a legal proceeding, as compared with more established methods that have already been subject to rigorous scientific scrutiny.

9. Scientific methods must be explained clearly and plainly. Courts must understand that geospatial technologies offer more than just a novel perspective on a crisis or other geographic phenomenon. Geospatial analysis is a scientific method that is subject to scrutiny and peer review. Analytical reports and expert testimony should be weighted accordingly.

10. Consider and be open to other potential explanations of the data being analyzed. If these can be excluded, be prepared to explain why and how. If alternative explanations are possible, but not probable, consider whether those probabilities can be quantified, and be prepared to do so.

11. In instances where technical vocabulary is necessary to appropriately describe a subject, be prepared to explain the meaning of terms to a lay audience. Analogies or metaphors may be helpful in these instances, however, the limitations of such comparisons must also be made explicit. It may help to consider such explanations in advance, to avoid having to analogize extemporaneously.

**Human rights NGOs**

12. Poorly performed analysis, or analysis with ambiguous results may have the potential to do more harm than good. Consult with an experienced, impartial analyst with an established record of performing analysis in legal contexts when determining the value of applying geospatial technologies in a given instance. In many instances, such an analyst may also be of assistance in performing the analysis itself.

13. Whenever possible, analysis of geographic data should be conducted in a way that isolates the process of analysis from irrelevant information that could prejudice the analysis. Examples of this would include value judgments concerning actions that
were taken, or media of alleged victims or perpetrators that are not associated with the project’s geographic context. When screening this information, however, care must be taken to ensure that analysts nevertheless have sufficient background information about the situation to conduct their analysis effectively.

Governments

14. Agencies such as the U.S. National Aeronautics and Space Administration (NASA), the U.S. National Oceanic and Atmospheric Administration (NOAA) the European Space Agency (ESA) that provide geospatial information collected for scientific purposes should be aware that those data may be used by actors, such as lawyers, with different standards and requirements from the scientific community. Where possible without compromising the primary scientific/institutional mission, efforts should be made to ensure that the data are compliant with the requirements of these communities as well, for example through documentation of chain-of-custody. In many cases, the requirements of the legal and scientific communities may overlap or be mutually-reinforcing.

15. When imagery is declassified for public access, every effort should be made to ensure that the metadata associated with images or other data is also made available, and referenced in a way that allows users of the primary data to access the parameters associated with it.

16. Refrain from enacting policies that unnecessarily limit the capabilities of non-government actors to make full use of the technological capabilities of non-government geospatial data.

Private suppliers of image data

17. Publicly state as much information as possible about the measures taken to protect images against manipulation.

18. Where technologies and methods cannot be disclosed because they are proprietary, consider conducting scientific studies, published in peer-reviewed journals, that verify image acquisition and storage accuracy and provide an error rate. This type of publication would allow courts to evaluate the reliability of such methods by comparing their results with known ground-truth, and would be very useful for expert witnesses who need to explain the credibility of the data underlying their analyses.
APPENDIX: Introduction to Geospatial Technologies

This section provides a broad overview of some of the most common types of geospatial technologies in use today and briefly describes their capabilities and how they function. Although the range of geospatial technologies is too broad for a practical, comprehensive cataloguing and description of them all, certain examples of the technology, such as Global Navigation Satellite Systems and remote sensing, are particularly ubiquitous.

Global Navigation Satellite Systems (GNSS) are space-based navigation systems that rely on constellations of satellites to provide location information anywhere on the earth’s surface. While the Global Positioning System (GPS) built by the United States Government is the most well-known of these, others such as the European Galileo and the Russian GLONASS are also in increasingly common use. GPS satellites contain synchronized atomic clocks that continuously broadcast the current time onboard the spacecraft. When coupled with precise knowledge of the spacecrafts’ orbits, GPS receivers can use the data from at least four satellites to triangulate their position on the earth’s surface. Today, handheld GPS receivers are ubiquitous, particularly in devices such as smartphones, and can locate their position to within 5 meters. High-end commercial receivers can provide readings that are accurate to less than a centimeter; the capabilities of military receivers are classified.123

123 Official U.S. government information about the Global Positioning System (GPS) and related topics https://www.gps.gov/systems/gps/
An example of satellite remote sensing: false-color high-resolution imagery of the area surrounding Bodo, Nigeria, following reports of an oil spill. (Image: DigitalGlobe)

**Remote Sensing** refers to the acquisition of information about objects or areas from a distance. Remotely sensed data are collected by active or passive sensors that are commonly mounted on satellites, manned aircraft, or unmanned aerial vehicles (UAVs). Active sensors, such as RADAR and LIDAR, gather data by emitting a signal and measuring the properties of the returned signal after it interacts with the surface that is being imaged. Passive sensors such as cameras, by contrast, detect natural electromagnetic radiation reflected from or emitted by objects. Sunlight is the most common type of reflected radiation, but specialized passive sensors such as thermal cameras can also detect the radiation that all objects emit in the infrared wavelengths as a result of their temperature. The spatial, spectral, and temporal resolution of remotely sensed data can vary widely depending on the specific properties of a given sensor and the platform on which it is mounted (e.g., aircraft, satellite, etc.).

**Mapping** is the process of creating a symbolic representation of selected characteristics of a place. Maps can be created at various spatial scales (the ratio of distance on the map to distance in the real world) and be used to display any type of geographic data. Recently, new technologies have allowed for the creation of interactive online maps served through platforms such as Google Maps or OpenStreetMap. Unlike printed maps, these web maps are able to dynamically display multiple data sets at different scales, update in real time,

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124 ESRI Support GIS Dictionary: Remote Sensing, Available at [http://support.esri.com/sitecore/content/support/Home/other-resources/gis-dictionary/term/remote%20sensing](http://support.esri.com/sitecore/content/support/Home/other-resources/gis-dictionary/term/remote%20sensing)

125 RADAR, or RAdio Detection And Ranging, is an active sensor that uses radio waves for detection. LIDAR offers similar functionality using optical wavelengths.

126 Spatial resolution refers to how many individual picture elements an image contains, and is often expressed in terms of those elements’ physical size, which can be envisioned as the size of the smallest resolvable object in an image. Spectral resolution refers to how finely the wavelengths of the electromagnetic spectrum have been divided, the colors of which provide information on the materials present in an image.

and empower users to select and display different data layers. In this regard, they exhibit some of the same functions as geographic information systems.

**Geographic Information Systems (GIS)** are computer systems for capturing, storing, editing, analyzing, and displaying location-based data. These systems allow for data captured from multiple sources at multiple scales to be displayed and analyzed together. There are many different GIS platforms available on the market today with different tools, capabilities, and price points, including QGIS, ArcMap, and GlobalMapper, to name just a few. Common across nearly all GIS software, however, is the ability to layer different datasets on top of one another, style data for map production, edit attribute data, assign projections, calculate distances between features, and perform spatial statistical analysis.

**Volunteered Geographic Information (VGI)** is a term that refers to location-based data that have voluntarily been created, assembled, or disseminated by individuals. In addition to spatial information, it typically contains a temporal component and is often, but not always, generated by electronic devices that are “location-aware” through the integration of satellite-based positioning systems. Location-based data are frequently made available via the internet and social media, and their nature ranges from highly granular (e.g., individual photographs with embedded location information) to highly aggregated (e.g., total reports of an earthquake over an entire region). Recently, there has been a proliferation of devices and software that allow individuals to create location-based data, resulting in detailed maps generated by thousands of users that can offer unique insights to local phenomena but which also, due to their open nature, have the potential to contain data that is of poor quality, or even deliberately misleading.

**Spatial Statistics** is a field of study concerning statistical methods that use the relationships between objects’ locations directly in their mathematical computations. These can be used for a variety of analyses including identifying patterns, measuring central tendency, shape analysis, spatial regression, and modeling spatial interaction. The many types of spatial statistics include descriptive, inferential, exploratory, geostatistical, and econometric statistics.

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3D Modeling/Mapping refers to the ability to analyze and present objects and areas in three dimensions. This can be used to create a more accurate representation of scenes in which the vertical dimension is important, such as mountainous terrain, buildings, or excavations. When done over large areas, it can be used to create Digital Elevation Models (DEM, also known as Digital Surface Models, DSM), which allow for additional analyses such as hydrologic mapping. When performed with traditional cameras, this discipline is known as photogrammetry. Data for three-dimensional maps is also routinely collected with RADAR and LIDAR.

Georeferencing is the process of aligning an image that does not contain embedded geographic information (for example, historical aerial imagery captured on film) to a geographic grid and map projection. This process often results in some warping or distortion of the original image. In instances where the image was acquired from a perspective other than toward nadir (i.e., straight down), this warping can be significant, and some degree of misalignment of the image is likely. The presence of significant terrain features (e.g., mountains with steep slopes) exacerbates this effect still further. Modern imagery uses digital elevation models to correct for terrain effects, however such corrections may not be feasible for older, non-digital imagery.

Ground Truth refers to information obtained from the surface of the earth in the area that is being studied using remote sensing. Ground truth is often used to test and validate the conclusions of the remote investigation. An example of this would be if users on social media posted images of military operations with embedded geodetic coordinates, and these were subsequently used to verify the conclusions of a remote sensing investigation.

Pan-sharpening is the process of using a high-resolution panchromatic (black and white) image to provide additional detail to a multispectral (color) image acquired at lower resolution. This technique is used because sensors that create color imagery must reduce their spatial resolution in order to increase their spectral (color) resolution. By fusing the two, the texture detail of the panchromatic image is applied to the color detail of the multispectral image, which greatly aids in interpretability. In such an image, however, spatial variations in hue and saturation are coarser than variations in luminosity.