IMAGES AND THE LAW

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Part 1 – Introduction and Index

This document illustrates the use of photos and images as part of various legal cases, compiled to give law professionals some background in the use of such graphic evidence, and its derivatives, in various cases. It is a guide for those who need to approach a project that contains images, or that would benefit from them. An effort was made to create a simple message that is directed more to practical applications than to the science.

The use of photography in accident cases is very well known, and therefore not covered in this document. Emphasis is made in applications of the science of photogrammetry to legal cases involving land in one form or another.

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Part 2 - Things that can be done with imagery

Imagery provides graphic detail that was collected with a camera or sensor. This detail can be studied in two dimensions (one image at a time), or within a three-dimensional (stereoscopic) workspace. The study can be the mere interpretation of detail, or it can involve precise measurement thereof.

Photo interpretation

The interpretation of image detail is a learned skill, since it requires the efficient recognition of natural and cultural features. Usually, many years or experience is necessary to give an interpreter the skill to correctly identify a vast array of possible scenarios and to extract all the information potential inherent in images. For example, the interpretation of the effects of a spill requires a detailed understanding of soils, drainage, vegetation, transportation, storage, etc. Also, their interactions must be recognized. For example, evergreens prefer growing in well-drained soils, a high-water table will have an impact on nearby vegetation, and the presence of historic fences is revealed by the type of vegetation underneath them.

For more information on interpretation, please advance to Part 7 in this document.

Measurement

Interpreted detail can be measured in two or three dimensions. This measurement can result in a set of numbers or in mapped detail. This detail is collected to satisfy a specific purpose, and the wholesale mapping of images is no longer done for legal cases.

Photogrammetric measurements are done with the help of specialized software tools that are designed to provide various technical means to safeguard the precision and accuracy of the
photography. This includes the ability to:

(a) Calibrate a camera, which helps remove lens distortions and other camera-internal image deformations;
(b) Introduce ground control to properly scale and orient digitized information; and
(c) Report precisions and accuracies of the digitized detail.

Therefore, the results of image interpretation, measurement or mapping can take the following general forms: (a) A document that contains recorded observations, (b) a table of specific measurements, and/or (c) a digital map that presents detail in a specific perspective view. Image portions normally accompany any one of these forms.

Integration

Information measured in photography is combined with other types of information. This generally includes:

(a) Some survey work on the ground to measure control points that are visible on the photography, and that are used to level, rotate and scale digitized detail; and
(b) Information from other sources, such as existing land surveys, environmental reports, soils studies, and many other possible data.
To illustrate the types of projects that can be handled with imagery, consider the figure to the left. It represents a plan view rendition of a data set of a 1,500-foot-long right-of-way that is subject to conflicting claims. This rendition is too hard to read, since the ROW is only 30 feet wide. Therefore, a perspective view was used instead, as shown in the figure below. The colored symbols are utility items, and the black line work represents fences and buildings, all of which were mapped photogrammetrically. The colored polygons represent various easements that were inserted from survey data. So, with the proper skills, a strong and precise exhibit can be prepared that is easier to read.
Another example is shown below. The image shows a tank which appears on historic small-scale aerial photography. On the original photographs, this tank is smaller than a grain of sand. However, it was possible to map it in three dimensions with photogrammetric tools, and to calculate the volume of the tank with sufficient accuracy for spill assessment.
Part 3 - Projects advanced with images

3.1 List of actual uses
Over many years, John Young, the owner of Colorado Aerial Photo Service, has been exposed to a large quantity of requests for historic photographs, and is sharing with us his list of recorded image-based projects with either an image interpretation component, measurement activities, or both. This is his list:

Environmental

- Mining waste and processing contamination and reclamation
- Waste disposal and landfill sites
- Industrial use past and present and potential contamination
- Containment & evaporation ponds
- Buried foundations, contamination, and utilities

Water use and water rights

- Evidence of agricultural water use
- Sand and gravel mining and subsequent water storage
- Riparian
- History and evolution
- Protection, restoration, sustainability
- Design
- Water district mapping past infrastructure
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- Rights of way
- Easements

Land rights

- Adverse possession
- Condemnation
- Surface rights, history, claims

Flood control and mapping

- Documentation of flood events-before and after
- Analysis of causes and corrective options
- Assignments of liability
- Quantitative estimates of damage

Past land use affecting present land use and values

- Coal mines
  - Subsidence
  - Ground water implications
- Sand & gravel followed by landfill
  - Methane
  - Ground stability
  - Contamination
- Sanitary landfills
  - Authorized (legal)
Unauthorized (Illegal)

- Oil and gas wells and distribution and storage infrastructure
- Slope stability: Natural terrain and man-made landslide and rock fall hazards
- Mine dumps and waste deposits

Forensic, criminal

- Grave site location
- Crime scene depiction and reenactment
- Accident analysis

Urban design, historic preservation, permitting and rights

- Documentation of past use and restoration planning
- Mapping of present conditions in context of past use
- Historic sites past layout and preservation
- Traffic analysis and roadway planning
- Building permitting, grandfathering
- Adverse possession, property line issues generally
- Historic land use vs. current zoning restrictions
- Condemnations and takings
- Development restrictions due to past use and natural hazards
- History of rights of ways, paths, and historic use to establish current rights
- Property boundary disputes (Fences, set-backs, unpermitted improvements, access roads)
Utility, water district, irrigation, railroad, streets, etc. All forms of easement and ROW

Measurements of extents, areas, and volumes (airborne and ground imagery)

- Sand & gravel
- Inventories
- Water storage volumes and surface area
- Power plant coal inventories and planning
- Wetland mapping and restoration
- Ecosystem and habitat mapping and planning
- Coal mine subsurface extents, subsidence, surface water patterns, groundwater effects
- Open pit extents, volumes, and future estimates
- Mining reclamation planning and estimation of volumes and costs
- Mapping of surface water contamination extents and preventive planning
- Mining spill documentation and liability estimations and calculations
- Flood event mapping and damage extent and value quantification
- Flood event contamination mapping (areas and volumes)
- Mining claims documentation
- Forestry and natural resource mapping
- Riparian mapping and wetlands

Miscellaneous land use history of interest:

- Railroad tracks and yards
- Airports
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- Amusement parks
- Reservoirs and ditches
- Historic sites and infrastructure
- Family history of land use (farms, neighborhoods)
- Cemeteries
Sources of images are normally limited to the following, depending on the level of resolution and/or accuracy that is required.

First, there is **existing historic photography**. Luckily, there are still parties, such as Colorado Aerial Photo Service ([http://www.coloradaerialphoto.com](http://www.coloradaerialphoto.com)), that hold such photography so that it is available to the general public for a fee. Also, public libraries, universities, and local and federal government agencies hold some images. The advantage of this historic photography is that it shows detail as it existed many years ago.

Second, a photogrammetrist can collect **new photography**, either from hand-held or drone-mounted cameras. The advantage is that one can choose exactly what detail one wants to study. The disadvantage is that one cannot go back in time and collect historic detail. That said, the photogrammetrist may be able to assemble evidence from various other sources, such as older plats, reports or data, and combine it with new imagery to end up with meaningful evidence.

Third, there are **satellite images**, which of late have a resolution of about 1 foot. They are of use in regional studies. Resellers of images from private sources like DigitalGlobe ([https://www.digitalglobe.com/products/advanced-ortho-series](https://www.digitalglobe.com/products/advanced-ortho-series)) or from government agencies like Landsat/USGS are found on the internet ([https://landsat.usgs.gov](https://landsat.usgs.gov)).

Fourth, there are **commercial map databases**, such as Google Earth ([https://www.google.com/earth](https://www.google.com/earth)). These databases provide information that is useful to create less-accurate detail that can be of use for various purposes. Nowadays, Google Earth does not charge a fee for the use of basic earth coverage.
Part 5 - Roles and Responsibilities

When it comes to properly evaluate evidence provided on imagery of the earth, it necessary to establish a clear purpose of that evidence. Once that is clear, a selection of professionals can be undertaken. In this document, emphasis is made on the analysis of land and the areas of application mentioned in Part 2.

The Surveyor

The surveyor’s mandate is strictly related to legal land boundaries. Most surveyors perform various types of work, but mapping and reporting the location of parcel boundaries is their core responsibility.

The Photogrammetrist

The trained and experienced photogrammetrist interprets imagery content and measures detail in a controlled environment using precise methods. For example, camera calibration prior to a project is of paramount importance when precise measurements are needed. The photogrammetrist should have a multidisciplinary education, and an extensive experience, to be able to recognize natural and cultural patterns, and to convert them to evidence. This professional is able to utilize historic and new imagery.

The Engineer

Although an engineer’s main responsibility is to develop designs, in photo interpretation the engineer performs calculations related to distance, areas, volumes, and hydrology (runoff, highwater marks, drainage, storm damage, etc.).
Part 6 - Image Analysis Flowchart

I need someone to interpret or witness something

Secure: Historic aerial images, and/or New aerial images (drone), and/or New field photography (hand-held)

Interpret images stereoscopically to detect natural/cultural features

Create a measurement environment for the photographs

Precisely measure selected detail using computerized tools

Combine with other data

Write report and create exhibits
The flowchart on the previous page illustrates the general steps taken during data gathering and processing. The various boxes contain the major steps involved.

The **first row** represents the initial interaction with the client to establish project purpose, scope, and results. This drives the project. The left box is for interpretation purposes, and the right one is for measurement work.

The **second row** deals with securing images, something necessary for both interpretation and measurement. The right box, the securing of ground control for proper scale, is necessary for measurement only.

The **remainder of the boxes** represents the actual work by the photogrammetrist.

The interpretation of images is done using a stereoscope to inspect images. If the original material involves film-based photography, it is scanned using a professional scanner at a resolution of 3600 or 4800 dots per inch (dpi) depending on work requirements. These resolutions exceed the native resolution of films, and therefore no detail is lost.

The measurement of images is done using a professional photogrammetric software package. It is essentially a three-dimensional CAD package that allows the precise extraction of photographic detail. The result is a collection of wire frames that represent the necessary detail, annotations, and sometimes three-dimensional surfaces over which photographic detail is draped.

The photogrammetrically mapped detail can be combined with other detail by inserting it into the three-dimensional data model. This includes parcel boundary data obtained from a surveyor, structural or hydrological detail as provided by an engineer, or any other desired information. This allows the creative preparation of exhibits.
Part 7 - A Picture is Worth a Thousand Exhibits

Lawyers can encounter cases where photography is part of the evidence, and where image information must be interpreted by an expert (normally a photogrammetrist). This imagery can be recent or historic, taken from an airplane, a drone or with a hand-held camera. Also, the expert can extract precise measurements and attest to their accuracy.

This image interpretation is generally called “aerial photo interpretation” even if the imagery did not come from an aerial camera.

For example, a city may want to know if a development existed at a certain date, and whether it had impacted a stream flow. Figure 1, a two thousand times enlargement of a 1996 aerial photo, provides evidence to the expert that a river channel was affected.

Figure 1

In this case, the mere use of a picture is insufficient evidence, unless an expert points out specific detail and justifies conclusions in an unassailable way. The benefits of using a photogrammetrist for such analysis are well known.

Another example would be when one party allows a second party to utilize lands for the purposes of providing access to a land-locked parcel. In Figure 2, the owner of the party to the right had access to that parcel for decades, but a new owner of the parcel to the left closed that access. This access is hard to see with the untrained eye within this very enlarged image from
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1985. However, the photogrammetrist recognized the necessary evidence, and was able to document it.

![Figure 2](image1.png)

This access was confirmed during ground-truthing in the field (Figure 3) by detecting patterns in the vegetation, drainage, soil compression and a very old impromptu gate in the barbed wire fence.

![Figure 3](image2.png)

In other words, the properly trained photo interpreter can quickly and efficiently extract useful evidence from image resources. For over a hundred years, photo interpreters have been
used by the military for stage analysis, by the mining industry for the detection of specific ore-bearing layers, by accident reconstruction specialists, and by Napoleon’s army to detect and measure enemy emplacements. Photogrammetrists were utilized by government agencies, such as FEMA, USGS, EPA, etc., to, for example, identify the effects of storm flooding, evaluate mine reclamation, and study the impact of spills and fires. In local governments, similar applications exist, which include efforts to track urban development, protect public lands from encroachment, and study accident scenes. In the private sector it is used for a wide range of purposes. The introduction of drone technology is an emerging and increasingly sophisticated addition to traditional practices.

Photo interpretation evidence is introduced to a case through a signed Expert Witness Disclosure, hopefully accompanied by the pertinent expert professional stamp and signature. It helps if the witness has meaningful credentials in photogrammetry, such as proven and formal training in aerial photo interpretation and graduate degrees. Such a person will not only help the lawyer with the preparation of meaningful and defensible exhibits but will enrich the case with sometimes unsuspected angles, insights and perspectives.

Unfortunately, the formal schooling for this specialty is not available in the US, except behind military doors. In any case, many years’ worth of experience will be necessary to properly recognize how natural and cultural causes produce specified image information. This can include natural interactions between soil types, vegetation (i.e. evergreens prefer well-graded soils, as can be seen near Buena Vista, Colorado), soil moisture, geology, and surface runoff. Cultural causes include all human-caused changes, such as traffic, digging, construction, filling, planting, harvesting, etc., and the introduction of external elements (water, fire, etc.).
professional photogrammetrist can create a well-balanced and complete picture from those visual cues to a degree not otherwise available. Of course, the measurement of features also falls under the expertise of a professional photogrammetrist. This includes, for example:

- Determining the volume of large excavations (Figure 4);
- Calculating stock pile volumes for inventory purposes (Figure 5);
- Preparing a time-stamped and scaled image of Dinosaur Ridge footprints (Figure 6) to document existing footprints and those already stolen;
- Capturing the dimensions of the fragile roof of Sanford Hall of Auburn University (Figure 7);
- Building a wireframe of a bridge, like the one for the historic Ely Bridge in Monticello, Iowa (Figure 8 and Figure 9) for the purposes of performing a finite-element stress analysis.

Evidence can gain impact using the right exhibits that target specific points in case. The applications are numerous, and they require the imagination of the lawyer to see how this helps strengthen cases, and how it helps the business of law.
Track Inventory - June 2011
Orthomap of Track Site
Scale: 1" = 2'

Figure 6
Figure 7
Figure 8

Figure 9
Part 8 – Legal Considerations
By Greg Cucarola, PC

Regarding the definition of photogrammetry, The Manual of Photogrammetry\(^1\) states that “Photogrammetry is the art, science, and technology of obtaining reliable information about physical objects and the environment through processes of recording, measuring, and interpreting photographic images and patterns of electromagnetic radiant energy and other phenomena.”\(^2\)

In said Manual of Photogrammetry, the procedures used for the mapping and interpretation of images can range from single-image ones, as in the case of the use of vanishing point geometries,\(^3\) to image pairs for the stereoscopic inspection and measurement of images,\(^4\) and to the use of multiple images to analyze the same object or multiple objects.\(^5\) It also states that “Figure 17-39 illustrates 9 strips from 9 orbital segments assembled into a block of 27 photographs.”

Also, the tome on “Interpretation of Aerial Photographs,”\(^6\) states that “Photo interpretation may be defined as the identification of objects on air photos and the determination of their meaning and significance.” and “…countless tactical military decisions were based on aerial reconnaissance missions.”\(^7\) It also states that “Only a small number of America universities offer graduate studies leading to the doctoral degree in photogrammetry or photo interpretation.”\(^8\) In addition, it mentions that “one of the widely recognized seats of photogrammetric training is the International Institute for Aerial Survey and Earth Sciences at Delft, The Netherlands, and it lists an excerpt of that institute’s statement of aims: “2. Standard courses of 12 to 18 months duration for a full training in aerial photo-interpretation as applied to natural resources inventory combined with an advanced training in selected subjects of integrated
The book on “Elements of Photogrammetry” states that Photogrammetrists and photo interpreters can obtain aerial photography in one of two ways: They can purchase photographs from an existing coverage or obtain new coverage” and “…existing coverage…may prove suitable … age, scale, camera…for reconnaissance or photo interpretation purposes…it is necessary to ascertain exactly what coverage exists in a particular area.”

As an expert, a photogrammetrist merely needs to examine the best photos available of a subject area, and then use their training, knowledge, experience and skills to report what the photos indicate. Evidentiary standards do not require a photogrammetrist to plan and take photographs of lands in anticipation of speculative future events. Often, photos from public records or reports will be available, meeting exceptions of CRE 803 (8).

“In photographic evidence, it is not necessary that the subject matter be completely outside the knowledge of jurors to justify the admission of expert testimony on the subject. Qualified photogrammetrists, by training, select the best photographs.

CRE 702 governs the admission of expert testimony. The Colorado Supreme Court
has ruled that, in determining whether expert testimony is appropriately admitted, the trial court should consider "the reliability and relevance of the proffered evidence" and "determine . . . (1) the reliability of the scientific principles, (2) the qualifications of the witness, and (3) the usefulness of the testimony to the jury." Trial courts should conduct a broad inquiry that considers the totality of the circumstances involved in each case.

In determining whether evidence is reliable, a trial court should consider two factors: (1) whether the scientific principles as to which the witness is testifying are reasonably reliable, and (2) whether the witness is qualified to opine on such matters.

CRE 702 is broadly phrased and provides that an expert may be qualified by any one of the five factors specified in the rule: knowledge, skill, experience, training, or education.

The Colorado Supreme Court has reinforced this liberal qualification standard by holding that a qualified expert witness need not "hold a specific degree, training certificate, accreditation, or membership in a professional organization."

In acknowledgement of photogrammetry’s usefulness and reliability, numerous cases have allowed expert testimony on photogrammetric analyses. In US v. Quinn, the Court admitted an FBI agent’s testimony of a bank robber's height calculated from bank surveillance photographs through the use of photogrammetry. The court found that the process used by the FBI agent was not novel and did not involve questionable scientific methods. The Court also held that by allowing the opportunity for Quinn to call his own expert witness regarding the FBI agent’s photogrammetric analysis, concerns regarding potential prejudice from the FBI agent’s testimony were addressed. The Court stated, “he [Quinn] was permitted to cross-examine the government's expert as to the specifics of the process, the techniques he used, and the witness's qualifications to give his
findings. The court gave Quinn the opportunity to call his own photogrammetry expert, which he did not do- although he had an expert in the courtroom during the government expert's testimony.”

A review of existing decisions regarding admissibility of expert witness and photogrammetry reveals a number of additional cases where testimony was allowed at trial including, but not limited to: *U.S. v. Williams* (holding that the technique of reverse projection photogrammetry was sufficiently reliable to satisfy the admission requirements of F.R.E. 702 in determining the height of a suspect captured on a surveillance camera); *Vincente v. City of Rome, Ga.* (expert sufficiently qualified to give testimony using photogrammetry to determine bullet trajectory); and *Chapman ex rel. Estate of Chapman v. Bernard's, Inc.* (finding that expert's opinion regarding space between spindles in a daybed based on the use of photogrammetry was not based on "junk science" and was sufficiently reliable to be admitted).

Qualifications of the Expert. Under C.R.E 702 photogrammetrists assist the trier of fact in understanding the evidence and determining facts in issue. Experts in the photogrammetry field may often also be engineers, architects or land analysts.

Ground-Truthing. It is not objectionable that limited historical photos are available, as many issues are resolved or confirmed by ground-truthing. With ground truthing, the photogrammetrist physically examines the site while considering the facts that historical photos indicate. This verification is routinely carried out to confirm that what is seen in the aerial photography is an accurate depiction of what is actually occurring, or what actually did occur, on the ground. A photogrammetrist’s training, education, experience and skill allow for proper analysis of historic photographs. Photogrammetrists only work at scales and quality of film that support a specific endeavor. Ground verification helps a photogrammetrist confirm what
he observed in the aerial photographs.

In conclusion, and regarding the use of imagery in court, lessons learned include the following:

1. All image-related evidence must be cross-referenced. Taking a set of images that create links between the various parts of a case, such as the item to be put in evidence, the location, the witnesses, and the time and date, strengthens a case. For example, a close-up image shows the hand of the expert pointing at the object. Moving out a bit, now one sees the whole expert (face visible) pointing at the object. Moving out some more, one sees the location of the object (i.e. a room), the expert pointing at the object, and a witness. Then, one image shows the expert standing in front of the building, holding the camera, or maybe a drone. One last image shows a close-up of the expert, holding the camera that was used to take the images, so that brand and model can be seen. If it is a drone, it’s FAA registration number is shown, and the pilot’s airman certificate is placed into evidence. All images are time and date stamped.

2. Every image must be accompanied by a witness.

3. Every image must be tightly linked to a specific piece of written evidence.

4. The fewest possible number of images should be used.

5. Every image must address only one specific piece of evidence.

6. Images retain jury attention much more effectively.

7. Images are worth more than a thousand exhibits.
Part 9 – Credits

The following contributed substantially to this document:

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Part 10 - Footnotes

3 Ibid., Chap. 14, “Rectification”, Figure 14-6.
4 Ibid., Chap. 12, “Plotting Machines with Mechanical or Optical Trains”, Figure 12-54, p. 635.
5 Ibid., Chap. 17, “Satellite Photogrammetry”, Figure 17-39, p. 920.
7 Ibid., Chap. 1, “The Development of Photo Interpretation”, p. 7.
8 Ibid., Chap. 1, “Photogrammetric Training”, p. 11.
15 *Shreck*, 22 P.3d 68, 70 (Colo. 2001).
16 Id.
17 Id.
18 Id. at 77.
20 Id.
21 United States v. Quinn, 18 F.3d 1461 (9th Cir. 1994).
22 Id. at 1465.
26 CRE 401.