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Legal Aspects of Photogrammetric Measurements for Surveying and Mapping*

A brief background of basic photogrammetry is given with its interrelationship to its acceptance in the courts of law.

In its simplest derivation, Photogrammetry is the science of making measurements on photographs. A photograph may be taken from the air, an aerial photograph, or from the ground, a terrestrial photograph. A photograph, either aerial or terrestrial, records on a medium (film or glass plate) the images viewed by the optical system of the camera used to take or expose the photograph. The resulting exposure in a negative form is later reproduced as a positive print or transparency, and negatives and positives are used in the preparation of maps and in the interpretation of terrain data.

Photogrammetry is not a new technique, although its use has become more widespread because of relatively recent scientific progress. The development of Photogrammetry has followed the discovery and application of basic mathematical principles; the invention and perfection of cameras, lenses, and film; the mechanical and optical development of stereoscopes and stereoscopic measuring and plotting instruments; the advancement of lighter-than-air (balloon) and heavier-than-air aircraft and auxiliary equipment; the availability of more efficient and reliable surveying instruments—the optical theodolite and electronic distance measuring instruments; and the combining of all these elements into practical applications for Surveying and Mapping. The pronouncements by ancient philosophers, mathematicians, and astronomers have been fulfilled in the production of perspective drawings in the early 1700's, through the use of the first cameras in the 1800's which were airborne in balloons in 1858, to our current sophisticated universal stereoplotting instruments which are producing highly reliable and accurate maps.

The history of Photogrammetry is resplendent with the names of German, Austrian, Italian, French, and British inventors. In our country we are indebted to George Eastman, the Wright brothers, Sherman Fairchild, Captain O. S. Reading, Harry Kelsh, Russell Bean, and many others in both government service and in private practice. A major contributor was Doctor Earl Church, Professor of Photogrammetry at Syracuse University. Dr. Church is known a the "Father of American Photogrammetry." He was an engineer, surveyor, and brilliant mathematician. He brought one of the first stereo plotting instruments (the Zeiss Multiplex) to this country (1931) and he developed basic mathematical solutions for the orientation of aerial photographs and for analytical aerotriangulation. His international renown brought students from all over the world to the University. His students, including this writer, are grateful for the opportunity of working with this extraordinary man.

Since World War II, Photogrammetric methods have been developed to include increasingly complex and difficult projects requiring rapid, precise measurements of places or things. While the mapping of the surface of the Earth at various scales has been the major requirement, Photogrammetric applications have included the analysis of new appliances to determine coordinate values which can be fed into a computer to direct and control assembly line operations; photographing flame and smoke inside the fire box of a blast furnace to determine the efficiency of combustion; reconstructing traffic accidents; motion analysis; measurement of cattle to determine weight distribution; medical research for a variety of studies including the anatomy (I've always said that if a surgeon is going to operate on me, I want him to have a good road map of the area); and, more recently, Photogrammetric techniques are being used to provide valid and acceptable evidence in courts of law. The potential scope of Photogrammetric applications is tremendous, and

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the field is aided by continuing developments in optics, electronics, computer science, and the ingenuity of Photogrammetric engineers and technicians.

Our courts have been slow in accepting at full value the use of aerial and terrestrial photographs and even more reluctant to accept maps and plats prepared by Photogrammetric methods. In the case of photographs the proverb, "One picture is worth ten thousand words," has paved the way for the admission of aerial and terrestrial photographs in criminal, civil, and administrative proceedings. However, information gathered and interpreted must be adjudged to be in compliance with the traditional rules of evidence. All aspects of Photogrammetric presentations require the work and knowledge of experts, and their products, maps, must meet the criteria of other types of scientific evidence.

It is an established principle in the law of evidence that photographs[1] of places or objects are admissable in evidence when the photographs are shown by extrinsic parol evidence or by other physical evidence to be accurate representations[2] of the subject at the time in question and when properly authenticated.[3]

Courts are fearful that they may be victimized by spurious manipulations of the photography to produce warped and erroneous data. Photographs have been ruled inadmissable when they were deemed to be inaccurate or not properly authenticated,[4] lacking proper foundation,[5] a substantial change of circumstances due to time lapse[6] or a lack of a necessary element of sufficient scientific establishment to have gained recognition or acceptance.[7]

It has been my experience that courts and opposing attorneys are eager to accept photographs once they are assured that they are truly authentic and that the expert presenting them is well informed and thoroughly qualified. Because photographs, either aerial or terrestrial, are rarely taken at a moment in time that corresponds with an accident or a circumstance of property, a clear relationship must be established between the time of photography and the event of the lawsuit. In Alabama, aerial photographs allegedly showing property at the time a condemnation application was filed were allowed to show the boundaries of the real property included on the photograph.[8]

Boundaries may be artificial or they may be functions of nature such as streams, woodslines, hedgerows, roads, cultivation lines, and the like. Such natural features are readily observed on an aerial photograph; however, the reliability of their location and measurement is a function of the scale, accuracy, and usability of the photograph itself.

Aerial photographs can be taken at an altitude to produce photographs at a scale from which reliable identification and measurements may be made to meet prescribed limits of accuracy. Obviously, the size and value of the properties involved, and the cost of performing the survey, are essential elements in the consideration of Photogrammetric work.

Within the past 40 years, I have witnessed substantial changes in Photogrammetric methods, accuracies, and costs for this work. In the mid-1930's the Tennessee Valley Authority initiated a vast program of regional development. This required a tremendous survey task which, among other things, included the mapping and acquisition of properties that would be inundated or otherwise affected by reservoir waters. In those days enlarged scaled aerial photographs were used in the field as a plane table sheet. Property corners which were located by deed and/or consultation with owners were tied into identifiable images such as a lone tree or a bush, fence corners, road and trail intersections, etc. These ties were made by short traverses run and plotted on the enlarged photographs. The field photos were sent to the office where a property map was plotted using radial line Photogrammetric techniques and basic photo control points that were established by third order traverses. This innovative method combined basic principles with a practical application to produce property maps of large areas where land values were relatively inexpensive.

The TVA expected legal challenges; however, after the initial "bugs" were removed from the procedures, the resulting maps where found to be good and they were accepted by the Courts of Tennessee.

Tax maps have been prepared by Photogrammetric methods. The first such maps utilized control scaled from U.S. Geological Survey quadrangle sheets and were used as a base for fitting property deeds together. Currently, properties are being assembled on Orthophoto base maps which are prepared using sophisticated analytical aerotriangulation to extend basic control and precision Orthophoto plotters. The accuracy of the resulting tax maps makes it possible to provide digitized coordinates for property corners, computation of property areas, and a reliable property record system. This technique is the basis for the preparation of cadastral maps which we expect will be funded within the near future.

[1] State of Vermont v. State of New York 417 U.S. 270 (1970): U.S. v. State of Louisiana, 394 U.S. 1 (1969) where numerous Photogrammetric pictures were employed to map the Louisiana coastline by the U.S. Coast and Geodetic Survey: and numerous other citations in the State of Texas, Alabama, New York, California, Iowa, Georgia, etc.

[2] Moyer v. U.S. 312 F. 2d 302

[3] Paquet v. U.S. 236 F. 2d 293, People v. Cherry, 48 Col. 2d 301

[4] Changler v. Russell 164 Ga. App. 758

[5] Moore v. McConnell 105 Ga. App. 758

[6] Major v. Hoppe 209 Va. 193

[7] U.S. v. Kilgus 571 U.S. F. 2d 508 (1978)

[8] McJemore v. Alabama Power Co. 285 Ala. 20

In some European countries, notably Switzerland, cadastral maps prepared by Photogrammetric methods are accepted by their Courts as *prima facie* evidence of property boundaries and corners. In making these maps, each property corner is located and panelled in advance of the aerial photography. Rarely does the American Photogrammetrist have all corners located and panelled. Corners and boundaries frequently are obscured and/or lost and the search, retracement, and restoration of corners is made after the Photogrammetrist prepares a map depicting the best available photographic location of corners and boundaries. The Photogrammetrist and the Land Surveyor must work together in the preparation of property maps.

In court, the rules of evidence provide that maps, drawings, and diagrams which are both relevant and material to the issues to be proven, and which are shown to be reasonable, accurate, and correct, are admissable in a trial to assist both the court and the jury in establishing the facts of a given case.[9] It is my opinion that property maps of certain areas can be prepared by Photogrammetric methods to an accuracy and correctness that will qualify them for admission in our courts. Unquestionably, all parts of a Photogrammetric survey must be documented as to methods used and accuracies to be expected. A Photogrammetric mapping project requires the execution of a number of individual operations. Each task demands the use of precise equipment and the work of skilled and fully trained personnel. Acceptable limits of accuracy for each operation are established and must be scrupulously followed in order to insure the accuracy and the reliability of the final maps. A typical Operation Plan would include the following:

- Project Planning
- Aerial Photography
- Field Surveys for Basic and Photo Control
- Analytical Aerial Triangulation, when Needed
- Stereo Map Compilation
- Office and Field Edit
- Cartography and Final Map Drafting

The responsible person in charge of the project must be qualified and professionally competent. Usually this person will present expert testimony in court. Because most courts and members of the legal profession are not familiar with Photogrammetric methods and techniques, extreme care and diligence must be used to thoroughly develop and explain all phases of the work.

Photogrammetry is not a substitute for Surveying; rather, it is a part of the overall Surveying, Mapping, Remote Sensing, and Photogrammetric Profession. The Photogrammetric process does not monument corners. As a long-time research project, I recommend the development of a technique whereby stakes can be thrown out of an aircraft during its photo mission, in such a manner that they will fall exactly on the various corners that define a specific property. When you have solved this problem, let me know.

The base map prepared by Photogrammetric methods can show all physical features associated with a property study, including the recognition and plotting of old land lines that may not be visible on the ground. Corners may be projected and/or computed from the map. In some jurisdictions (Alaska and some western states) in relatively inaccessible areas, the Photogrammetrist has identified at least three images of lone trees, bushes, etc. adjacent to projected boundary corners. These points are plotted and coordinated on the base map. The Land surveyor uses these values to resect his position in the field and to locate and stake the coordinate position of the property corner.

As previously stated, the ramifications and magnitude of problems that can be solved by photogrammetric methods is very great, and practitioners should be knowledgeable and qualified in both Surveying and Engineering.

Should the Photogrammetrist be licensed in the State of his practice? This has been a thorny issue in many jurisdictions. California has wrestled with the problem and the Photogrammetrist has gone through licensure as a Civil Engineer, Photogrammetrist, and Surveyor. Many States do not require a special license for Photogrammetrists,[10] while others regard the Photogrammetrist within Engineering or Surveying.[11] Pennsylvania includes "aerial photogrammetry" within its definition of the Practice of Engineering.[12] It seems reasonable to conclude that persons in responsible charge of a Photogrammetric mapping project should be licensed, and, certainly, when boundary or property surveys are undertaken, the Photogrammetrist should be licensed as a Professional Land Surveyor or associated with a Registered Land Surveyor for this work.

Terrestrial photographs and Photogrammetric measurements made from them have been used extensively in many European Countries in the investigation of accidents. Only limited use of these techniques has been made in this Country. The work had been impeded by the cost of the necessary stereo cameras (photo theodolites) and the belief of law enforcement agencies that such investigations should be conducted by police officials. It is true

[9] State of Vt. v. State of NY 417 U.S. 270 (1974) and U.S. v. State of Louisiana. . . . see r.1 Supra

[10] Currently, Arkansas, Colorado, the District of Columbia, Georgia, Hawaii, Kansas, Louisiana, Maine, New York, New Mexico, North Dakota, Ohio, Oregon, South Dakota, Texas, and Utah.

[11] Currently California, Illinois, Kentucky, Mississippi, Minnesota, Missouri, Nebraska, Nevada, South Carolina, and Virginia.

[12] Prof. Engr. Law as amended.

that the police are first on the scene of an accident, and, if a substantial number of police units were equipped and personnel trained to obtain critical photos a short time after an auto accident occurs, the cost would be high. It is my recommendation that most municipalities should have one, or possibly two, trained and fully-staffed units available at all times to respond to accident calls. A single central Photogrammetric unit can process and plot the data appearing on the photographs, and the testimony of these experts should be admissable in Court.

The timing of the ground photography is critical; however, I have found that photographs taken some time after an accident, along with measurements and fully authenticated maps of the scene, are of great value to an attorney in presenting his case to a judge and a jury.

Recent development of cameras and stereo plotters and computers makes it important that this vital service to the legal profession be expanded.

In my contacts with members of the legal profession, I am appalled at their lack of knowledge of our capabilities. We must take every opportunity to acquaint them with information concerning the use of surveys and Photogrammetry in the solution of many of their cases. It is imperative that we should build confidence and professional respect for our work. Regretfully, as we well know, a poorly planned and executed mapping project can destroy a favorable appreciation of Photogrammetric capabilities.

To me, the key to the acceptance of Photogrammetric methods by our courts of law lies in continual diligence to meet professional standards of work, and the enhancement of individual professional and technical competence.

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Short Courses
George Washington University Continuing Engineering Education

Washington, D.C.

The following courses of interest will be given:

Mapping from Space: Techniques & Applications (7-11 May 1984)

This course will enable participants to understand the techniques for converting Landsat and other Earth sensing data into cartographic products. There will be a "hands-on" class exercise on the laying of controlled mosaics and two sessions devoted to the digital approach to image mapping. Concepts involving future mapping systems are also presented and include the deliniation of topography as well as planimetric features.

Synthetic Aperture Radar with Remote Sensing Applications (4-7 June 1984)

Completion of the course should enable participants to identify the fundamental concepts and physical aspects of synthetic aperture radar (SAR), apply it to the design of high-resolution sensor systems used in remote sensing applications, and create information products to match user needs. The course is intended for radar system designers and users, engineers, systems analysts, image interpreters, and others who need an update on the latest SAR technology.

For further information please contact

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